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SUMMARY OF THE GEOLOGY OF THE CHICAGO AREA

H. B. Willman

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ILLINOIS STATE GEOLOGICAL SURVEY

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John C. Frye, *Chief*

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SUMMARY OF THE GEOLOGY OF THE CHICAGO AREA

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ABSTRACT

The general geology of northeastern Illinois, an area inhabited by more than seven million people, is important in regional planning of land use, in construction of foundations, tunnels, dams, highways, and other structures, in the development and conservation of natural resources, and in improvement of the urban environment. The area described, called the Chicago area, extends from Lake Michigan westward to the Fox Valley and from Wisconsin southward to the Illinois Valley. It includes Chicago, its suburban cities, and the belt of cities in the Fox, upper Illinois, and Des Plaines Valleys.

The geologic map that accompanies this report shows the distribution of the various glacial and bedrock units that directly underlie the surface. The glacial units were deposited by the Lake Michigan Lobe of the Wisconsinan glacier that flowed over the Chicago area and built at least 19 moraines during a pulsing retreat. The materials deposited include tills of various compositions; sand and gravel deposited by streams and rivers flowing from the glaciers and by the discharge from glacial lakes; and sand, silt, and clay deposited in lakes dammed by the glaciers. After the ice retreated from the area, lacustrine deposits accumulated in Lake Chicago, the wind blew sand into dunes and deposited a thin mantle of silt on the uplands, peat accumulated in the many lake basins, the rivers and streams deposited alluvium in their floodplains, and the Modern Soil developed on all the deposits.

The geologic map also shows the areas where bedrock formations of Ordovician, Silurian, and Pennsylvanian age crop out. About 5,000 feet of Paleozoic bedrock formations overlie the Precambrian surface, but only the upper 1,000 feet are exposed in the area. The major structural features of the bedrock are the Kankakee Arch, the Sandwich Fault Zone, and the Des Plaines Disturbance.

The area has a variety of physiographic features—the rugged topography of the moraines, the flat plain of

Lake Chicago, the bedrock hills protruding through the glacial drift, the channels of the Chicago Outlet entrenched in bedrock, the sluiceways eroded by glacial floods and by discharge from glacial lakes, and the bluffs and beaches of Lake Michigan.

The mineral resources of the area have been an important asset in the building of its cities. They include dolomite and limestone, sand and gravel, clay and shale, coal, and both surface and ground water.

INTRODUCTION

The Chicago metropolitan area, encompassing the City of Chicago, its suburbs, and the surrounding region, has a population of more than seven million people. Among the most important factors influencing the growth and development of the area have been its geographic position and its geologic setting. Because of its location at the head of Lake Michigan, the Chicago of the early nineteenth century had water transportation to eastern cities and through the Illinois Valley to midwestern markets. When the railroads arrived in the middle of the century, they converged at the head of the lake, and Chicago became a railroad center. The transportation systems gave Chicago an advantageous situation for growth of its manufacturing and agricultural industries. The nearby mineral resources provided the crushed rock, building stone, sand, gravel, coal, brick, and water needed for the rapid growth of the city to its present eminence.

The geological setting of Chicago on a broad plain underlain by easily excavated sediments, which in turn are underlain by bedrock suitable for supporting large buildings, also favored its growth. The surrounding hills provided attractive areas for residential communities, and beyond them the valleys of the major rivers, the Des Plaines, Fox, Du Page, and Illinois, provided favorable topography, water, drainage, and mineral resources for the development of a belt of large industrial cities.

Study of the basic geology of the region, needed for the development of mineral resources and the solution of engineering problems, began in the early 1800s (Sauer, 1916). The engineers who designed and constructed the Illinois and Michigan Canal, which was opened in 1848 to connect Lake Michigan with the Illinois River, had to know the topography well. They also found sites where stone for building locks and dams could be quarried, discovered beds of dolomite of the proper composition for burning to natural cement that was used in constructing the canal, and opened gravel pits for road materials.

The earliest state-supported geological work in the area was published as brief reports on the counties (Bannister, 1868, 1870; Bradley, 1870), but no geologic maps were included. In 1902 the U.S. Geological Survey published the Chicago Folio (Alden, 1902) of topographic and geologic maps covering an area about 35 miles long (north-south) and 25 miles wide, most of it in the Chicago Lake Plain. When greatly improved topographic maps became available for a somewhat larger area (55 miles long and 25 miles wide), the geology was remapped by the Illinois State Geological Survey (Bretz, 1943) and two comprehensive reports on the geology of the area were published (Bretz, 1939, 1955). The geologic map included with the present report (pl. 1) covers a much larger area, 80 miles long and 50 miles wide, which is referred to as "the Chicago area" in this report.

Geologic information has been recognized through the years as essential for locating and extracting mineral resources, for developing ground-water supplies, and for determining foundation conditions for major structures. Today's rapidly increasing problems of waste management, drainage, and planning effective land use for improvement and growth of the metropolitan area have created a much greater demand for geologic information. This type of special application of geologic data is called "environmental geology" (Frye, 1971). This report presents a general, though brief, summary of the basic geologic data that must be the starting point for those who need geologic information for the solution of specific problems. It is not intended to furnish solutions for the many problems that are constantly encountered in the Chicago area.

The map (pl. 1) shows the distribution of the many different rock types that are exposed or directly underlie the surface soil. The text discusses their origin and explains their classification and general character. Brief descriptions of the deeper rock formations, of the land forms of various types, and of the mineral resources of the area also are included.

Geologic Setting

The geological setting of the Chicago area is shown by two regional maps, one showing the distribution of the bedrock units (fig. 1) and the other the distribution of the glacial deposits that overlie the bedrock (fig. 2).

The bedrock formations are exposed only in the southern half of the area, where glacial and modern rivers have cut through the glacial deposits and where quarries and mines have been opened. The glacial deposits, called drift, mantle more than 95 percent of the area and consist of unconsolidated till, silt, clay, sand, gravel, and peat. They are sharply differentiated and readily distinguished from the much older, consolidated bedrock formations that consist of dolomite, limestone, sandstone, shale, claystone, and coal.

The Chicago area is on a broad, gently sloping arch of the Paleozoic bedrock formations. This arch, called the Kankakee Arch, connects the Wisconsin Arch and the Cincinnati Arch and separates two broad depressions - the Illinois Basin to the southwest and the Michigan Basin to the northeast (fig. 1). The northeastern part of the Chicago area is on the northeastern flank of the arch, as is indicated by the eastward dip of the Silurian formations. The extreme southwestern part of the area is on the southwestern side of the arch, as is shown by the southwestward dip of the Pennsylvanian formations. Stream and glacial erosion truncated the arch and produced a surface that in broad aspects is a plain. As a result, the older rocks are exposed along the axis, or crest, of the truncated arch and the younger rocks are exposed in the bordering basins.

The entire Chicago area was buried under several thousands of feet of glacial ice that spread over the region from the northeast during the Wisconsinan glaciation—the last major advance of the ice. The glaciers were largely part of the Lake Michigan Lobe (fig. 2) but possibly included the margin of the Saginaw Lobe in the extreme southeast and the Green Bay Lobe in the extreme northwest. The Wisconsinan glaciers spread westward nearly to the Mississippi River and southward to central Illinois, and they eroded the Chicago area so intensely that no deposits of earlier glaciers have been found. It is reasonably certain that glaciers of the Illinoian glaciation, which preceded the Wisconsinan, advanced from the Labradorean Center of accumulation in eastern Canada and covered the Chicago area. Deposits of the Illinoian glaciation buried by younger deposits may remain in some of the bedrock valleys. As deposits of the still earlier Kansan glaciers are present southwest of the Chicago area, the northern edge of a Kansan glacier from the northeast also may have covered part of the region. There is no evidence to suggest that glaciers of the earliest glaciation, the Nebraskan, covered the Chicago area.

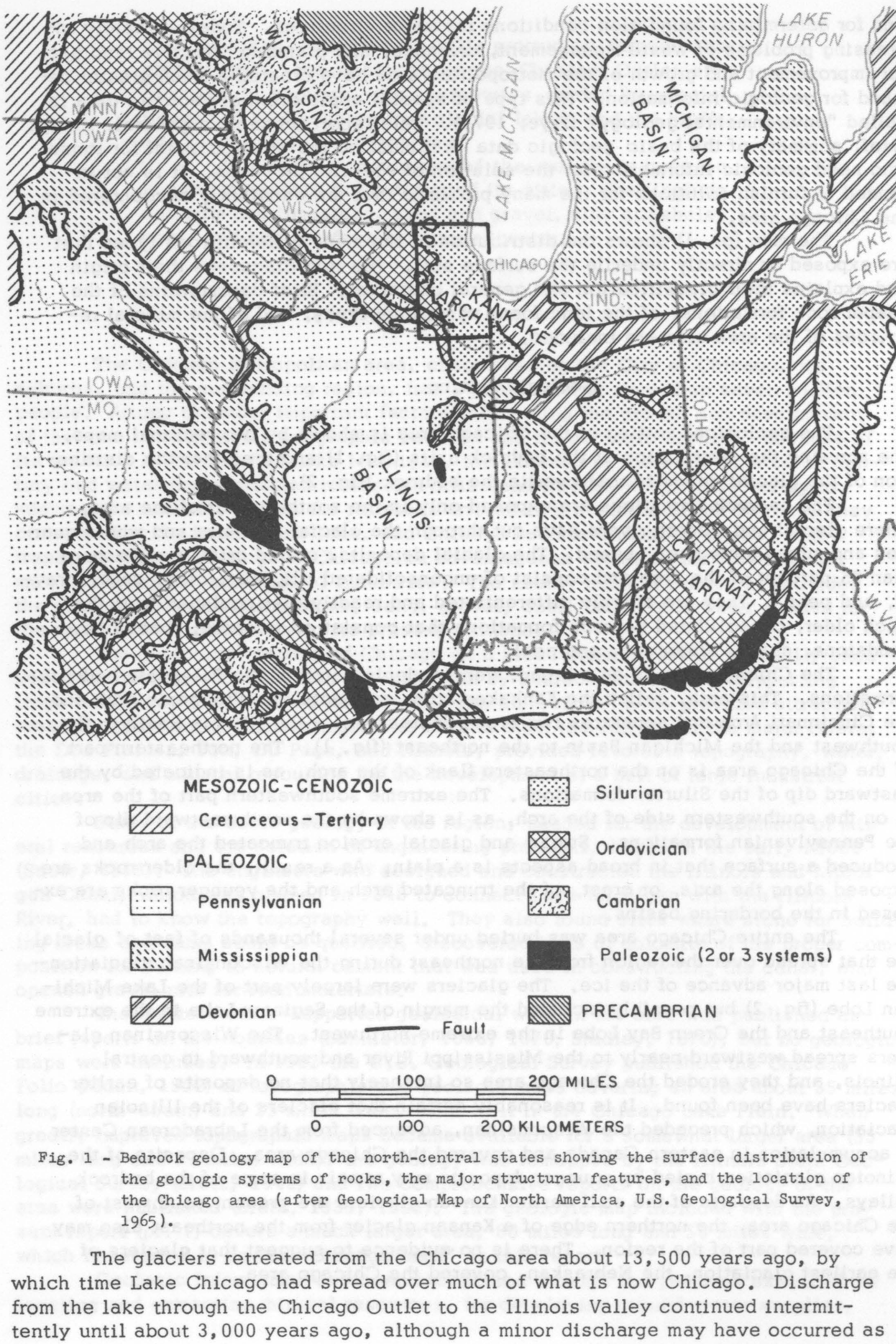


Fig. 1 - Bedrock geology map of the north-central states showing the surface distribution of the geologic systems of rocks, the major structural features, and the location of the Chicago area (after Geological Map of North America, U.S. Geological Survey, 1965).

The glaciers retreated from the Chicago area about 13,500 years ago, by which time Lake Chicago had spread over much of what is now Chicago. Discharge from the lake through the Chicago Outlet to the Illinois Valley continued intermittently until about 3,000 years ago, although a minor discharge may have occurred as

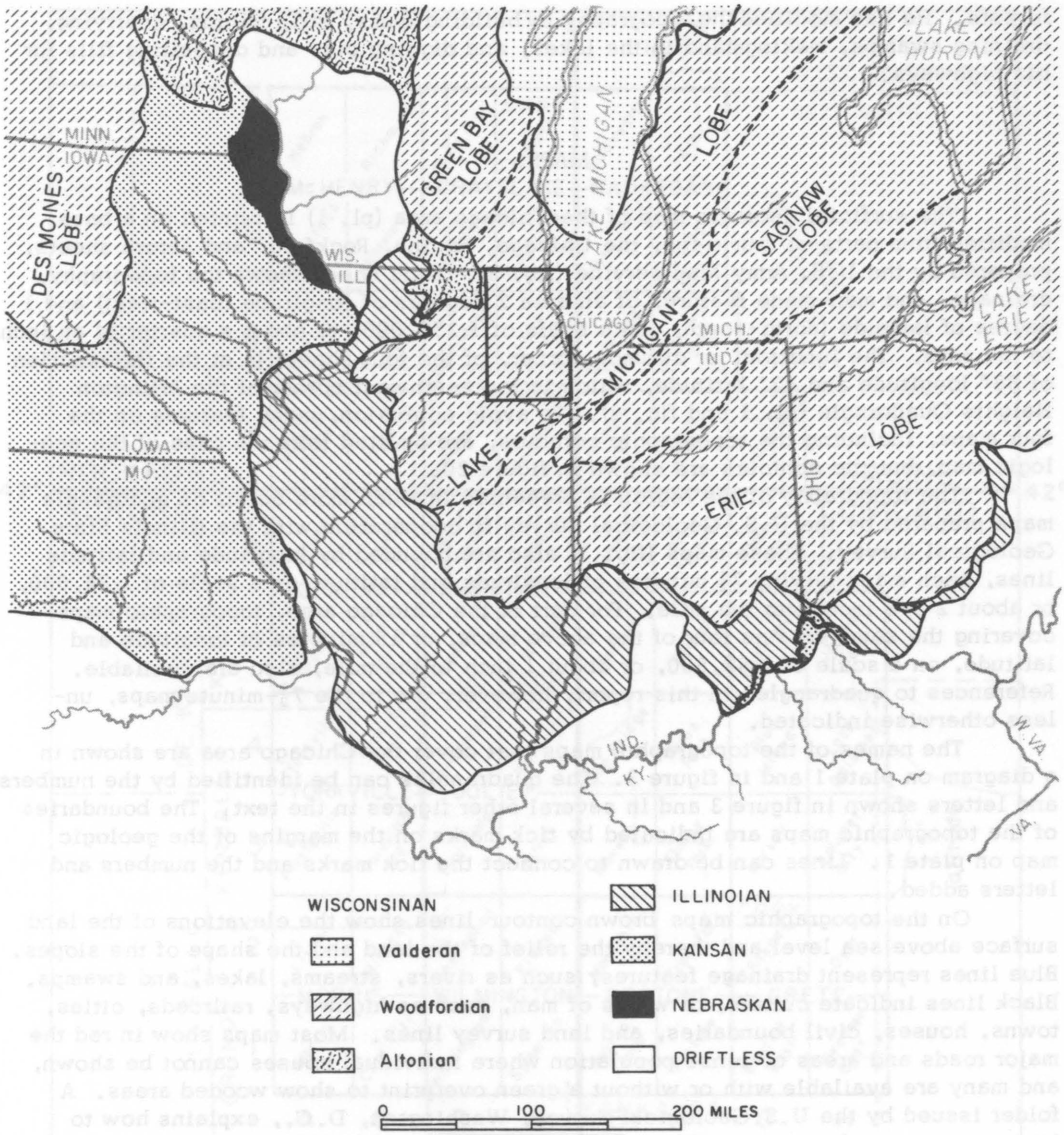


Fig. 2 - Glacial geology map of the north-central states showing the surface distribution of the major drift sheets, the principal Wisconsinan glacial lobes, and the location of the Chicago area (after Flint et al., 1959).

recently as 2,000 years ago. When the glaciers melted, a thin deposit of wind-blown silt (loess) blanketed the area; lakes formed in the depressions, eroded their shores, and made beaches; streams entrenched themselves and began building floodplains; the winds blew sand from the glacial outwash into dunes; vegetation covered the land; and weathering began the process of soil formation.

These processes are still going on. Many of the lake basins have been filled, or partly filled, with silt and peat, and the soil and forests have stabilized the sand dunes and reduced erosion by the streams. To some extent man has reversed the natural processes by tilling the soil, overgrazing the pastures, and cutting the forests. He has modified the topography by building dams, strip mining, quarrying, draining swamps, making land in the lakes, and digging cuts and depositing fills for his highways.

MAPS

The surficial geologic map of the Chicago area (pl. 1) is printed on a base modified from parts of four maps, the Chicago, Racine, Rockford, and Aurora sheets, prepared by the U.S. Army Map service (fig. 3). Each sheet shows the topography, drainage, and man-made features of an area 2 degrees of longitude (east-west) and 1 degree of latitude (north-south), on a scale of 1:250,000, or about a quarter of an inch to the mile. The junction, or common corner, of the four sheets is at the intersection of 88° longitude and 42° latitude, which is the southwest corner of the Arlington Heights Quadrangle (pl. 1 and fig. 3). To avoid confusion, many features on the four maps, including the topographic contours, are omitted from the base of the geologic map, but the contours are shown in figure 20.

The topography of the region is presented in much more detail on quadrangle maps prepared by the U.S. Geological Survey in cooperation with the Illinois State Geological Survey. These maps (fig. 3) also are bounded by longitude and latitude lines, each map covering 7½ minutes of longitude and latitude on a scale of 1:24,000, or about 2 5/8 inches to the mile. For part of the Chicago area, topographic maps covering the same area as four of the above maps, or 15 minutes of longitude and latitude, on a scale of 1:62,500, or about 1 inch to the mile, also are available. References to quadrangles in this report, however, are to the 7½-minute maps, unless otherwise indicated.

The names of the topographic maps that cover the Chicago area are shown in a diagram on plate 1 and in figure 3. The quadrangles can be identified by the numbers and letters shown in figure 3 and in several other figures in the text. The boundaries of the topographic maps are indicated by tick marks on the margins of the geologic map on plate 1. Lines can be drawn to connect the tick marks and the numbers and letters added.

On the topographic maps brown contour lines show the elevations of the land surface above sea level and thereby the relief of the land and the shape of the slopes. Blue lines represent drainage features, such as rivers, streams, lakes, and swamps. Black lines indicate culture, or works of man, such as highways, railroads, cities, towns, houses, civil boundaries, and land survey lines. Most maps show in red the major roads and areas of dense population where individual houses cannot be shown, and many are available with or without a green overprint to show wooded areas. A folder issued by the U.S. Geological Survey, Washington, D.C., explains how to interpret topographic maps. The maps may be purchased from the U.S. Geological Survey or the Illinois State Geological Survey.

The topographic maps have many uses in the study of the geology of the area. Most of the geologic boundaries on plate 1 occur where there is a change in the slope of the land. These changes are shown by the spacing of the contours on the topographic map. The geologic map (pl. 1) was made by drawing the boundaries of the geologic units on the topographic maps and photographically reducing them to the scale of the finished map. Consequently, by the reverse procedure - enlarging an area of the geologic map to the size of the topographic map - a geologic map can be made for each topographic map. The boundaries can be shown in much more detail than on plate 1 if the boundaries on the enlargement are adjusted to follow the topographic contours.

Several types of geologic maps have been used to show the various characteristics and physical relations of the rock formations in the Chicago area:

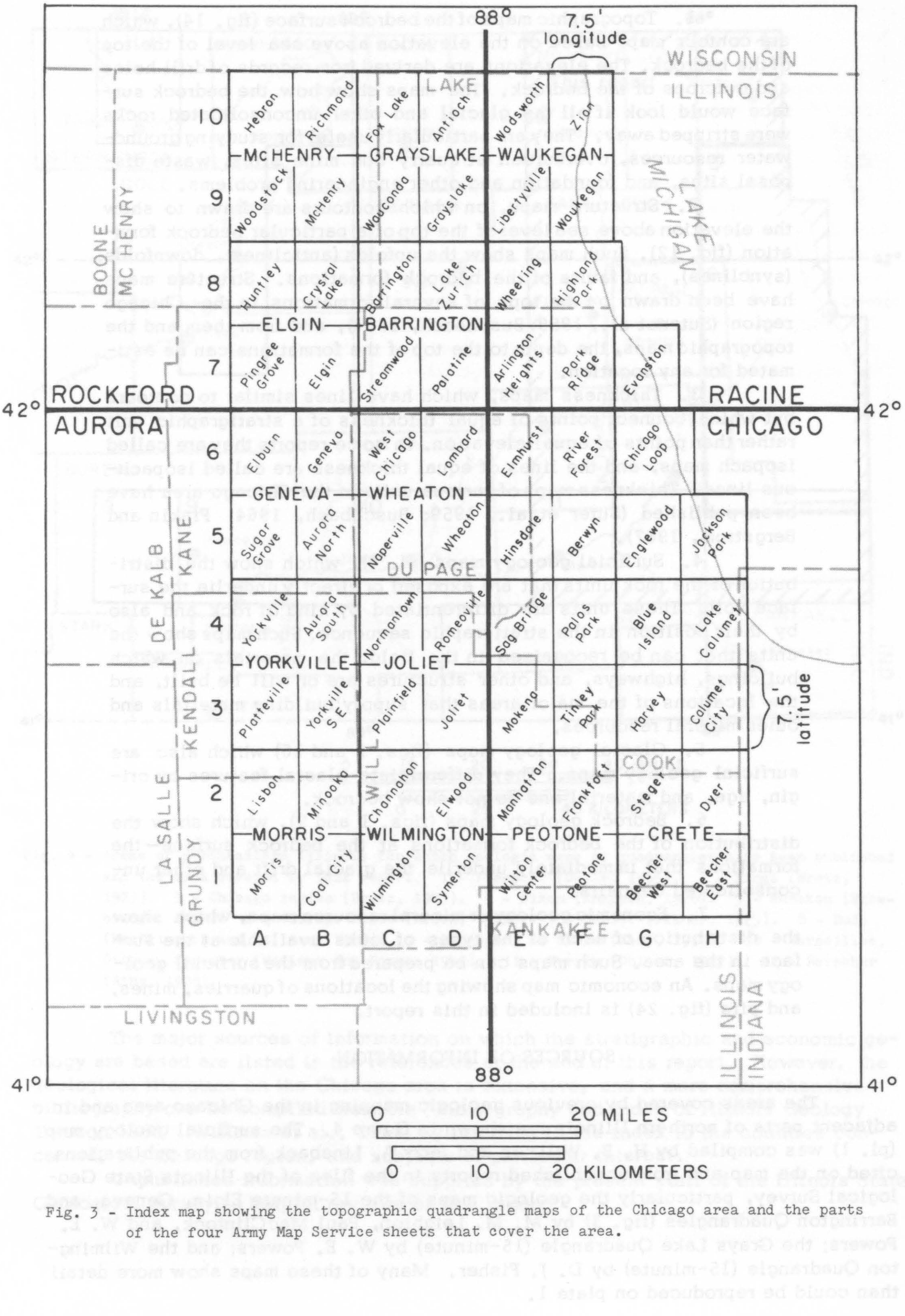


Fig. 3 - Index map showing the topographic quadrangle maps of the Chicago area and the parts of the four Army Map Service sheets that cover the area.

1. Topographic maps of the bedrock surface (fig. 14), which are contour maps based on the elevation above sea level of the top of the bedrock. The elevations are derived from records of drill holes and outcrops of the bedrock. The maps show how the bedrock surface would look if all the glacial and other unconsolidated rocks were stripped away. They are particularly useful for studying groundwater resources, overburden at quarry and mine sites, waste disposal sites, and foundation and other engineering problems.

2. Structure maps, on which contours are drawn to show the elevation above sea level of the top of a particular bedrock formation (fig. 12). Such maps show the upfolds (anticlines), downfolds (synclines), and faults of the bedrock formations. Structure maps have been drawn on the tops of several formations in the Chicago region (Suter et al., 1959; Buschbach, 1964), and from them and the topographic maps, the depth to the top of the formations can be estimated for any location.

3. Thickness maps, which have lines similar to contours but which connect points of equal thickness of a stratigraphic unit rather than points of equal elevation. In some reports they are called isopach maps, and the lines of equal thickness are called isopachous lines. Thickness maps of various units in the Chicago area have been published (Suter et al., 1959; Buschbach, 1964; Piskin and Bergstrom, 1967).

4. Surficial geology maps (pl. 1), which show the distribution of the rock units that are exposed or directly underlie the surface soil. These units are differentiated by kind of rock and also by their position in the stratigraphic sequence. Such maps show the units that can be recognized in the field, the materials on which buildings, highways, and other structures are or will be built, and the locations of the major areas that supply building materials and other mineral resources.

5. Glacial geology maps (figs. 2 and 16) which also are surficial geology maps. They differentiate glacial features by origin, age, and material and do not show bedrock.

6. Bedrock geology maps (figs. 1 and 9), which show the distribution of the bedrock formations at the bedrock surface—the formations that immediately underlie the glacial drift and other unconsolidated deposits.

7. Economic geology or mineral resource maps, which show the distribution of each of the types of rocks available at the surface in the area. Such maps can be prepared from the surficial geology maps. An economic map showing the locations of quarries, mines, and pits (fig. 24) is included in this report.

SOURCES OF INFORMATION

The areas covered by previous geologic mapping in the Chicago area and in adjacent parts of northern Illinois are shown in figure 4. The surficial geology map (pl. 1) was compiled by H. B. Willman and Jerry A. Lineback from the publications cited on the map and from unpublished reports in the files of the Illinois State Geological Survey, particularly the geologic maps of the 15-minute Elgin, Geneva, and Barrington Quadrangles (fig. 3) by M. M. Leighton, Paul MacClintock, and W. E. Powers; the Grays Lake Quadrangle (15-minute) by W. E. Powers; and the Wilmington Quadrangle (15-minute) by D. J. Fisher. Many of these maps show more detail than could be reproduced on plate 1.

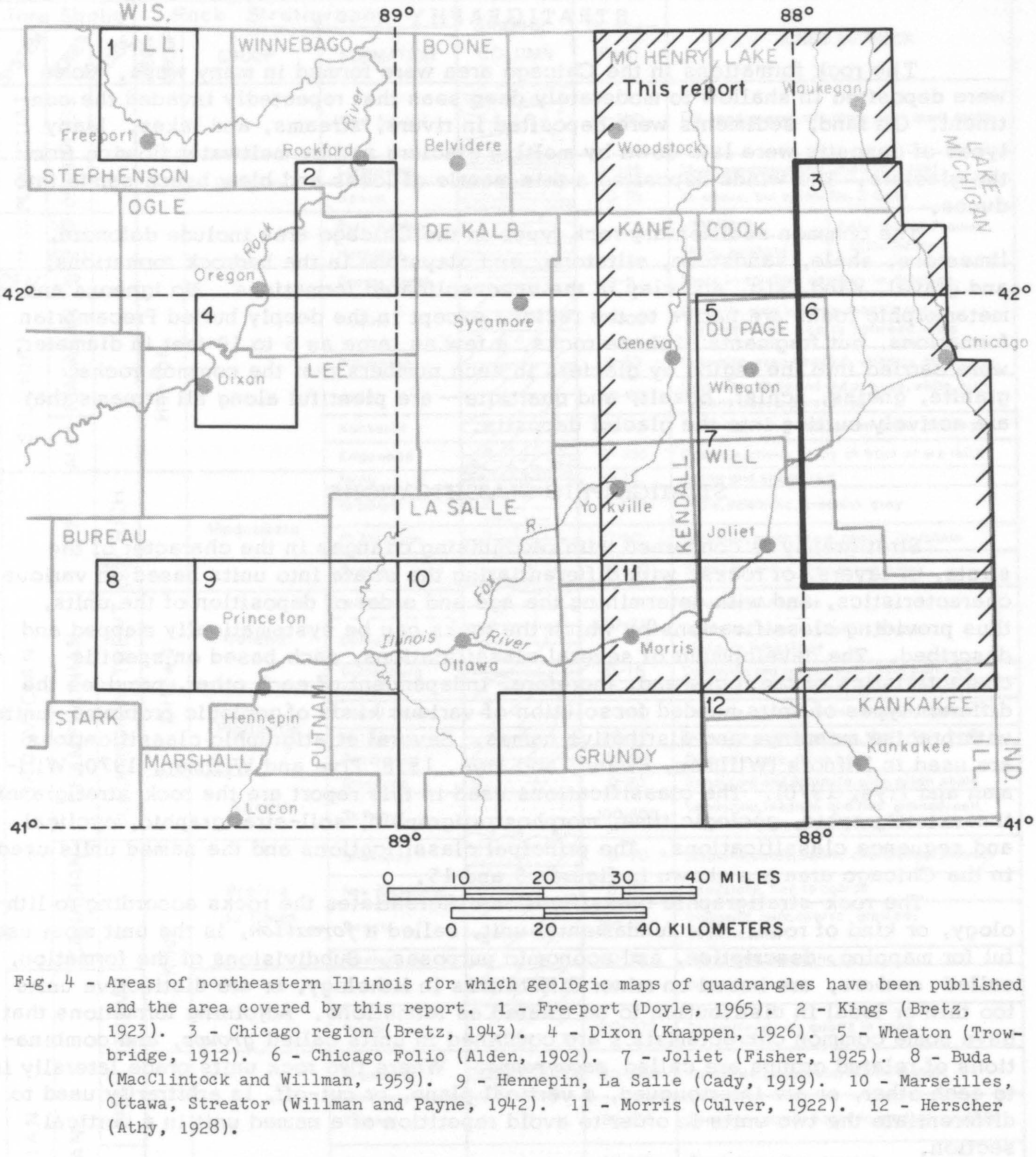


Fig. 4 - Areas of northeastern Illinois for which geologic maps of quadrangles have been published and the area covered by this report. 1 - Freeport (Doyle, 1965). 2 - Kings (Bretz, 1923). 3 - Chicago region (Bretz, 1943). 4 - Dixon (Knappen, 1926). 5 - Wheaton (Trowbridge, 1912). 6 - Chicago Folio (Alden, 1902). 7 - Joliet (Fisher, 1925). 8 - Buda (MacClintock and Willman, 1959). 9 - Hennepin, La Salle (Cady, 1919). 10 - Marseilles, Ottawa, Streator (Willman and Payne, 1942). 11 - Morris (Culver, 1922). 12 - Herscher (Athy, 1928).

The major sources of information on which the stratigraphic and economic geology are based are listed in the references at the end of this report. However, the geological literature on the Chicago area is extensive, and a more comprehensive bibliography can be compiled from the "Bibliography and Index of Illinois Geology Through 1965" (Willman et al., 1968) by referring in the index to the counties concerned, the Chicago region, and subjects of particular interest.

Unpublished information was supplied by the present staff of the Illinois State Geological Survey in helpful reviews of this report.

STRATIGRAPHY

The rock formations in the Chicago area were formed in many ways. Some were deposited in shallow to moderately deep seas that repeatedly invaded the continent. On land, sediments were deposited in rivers, streams, and lakes. Many types of deposits were laid down by melting glaciers and by meltwater flowing from the glaciers. The winds deposited a thin mantle of loess and blew beach sands into dunes.

The common sedimentary rock types in the Chicago area include dolomite, limestone, shale, sandstone, siltstone, and claystone in the bedrock formations, and gravel, sand, silt, and clay in the unconsolidated formations. No igneous and metamorphic rocks are native to the region, except in the deeply buried Precambrian formations, but fragments of these rocks, a few as large as 5 to 10 feet in diameter, were carried into the region by glaciers in such numbers that the common rocks granite, gneiss, schist, basalt, and quartzite — are plentiful along all streams that are actively cutting into the glacial deposits.

STRATIGRAPHIC CLASSIFICATIONS

Stratigraphy is concerned with recognizing changes in the character of the strata, or layers, of rocks, with differentiating the strata into units based on various characteristics, and with determining the age and order of deposition of the units, thus providing classifications by which the rocks can be systematically mapped and described. The development of several classifications, each based on specific characteristics of the rocks and, therefore, independent of each other, provides the different types of units needed for solution of various kinds of geologic problems—units with precise meanings and distinctive names. Several stratigraphic classifications are used in Illinois (Willman, Swann, and Frye, 1958; Frye and Willman, 1970; Willman and Frye, 1970). The classifications used in this report are the rock-stratigraphic, time-stratigraphic, geologic time, morphostratigraphic, soil-stratigraphic, cyclical, and sequence classifications. The principal classifications and the named units used in the Chicago area are shown in figures 5 and 15.

The rock-stratigraphic classification differentiates the rocks according to lithology, or kind of rock. The fundamental unit, called a *formation*, is the unit most useful for mapping, description, and economic purposes. Subdivisions of the formation, called *members*, are based on minor differences in lithology, or are distinctive units too thin or local in distribution to be treated as formations. Adjoining formations that have some common characteristics are combined in units called *groups*, and combinations of related groups are called *megagroups*. Where two rock units grade laterally into each other, or are intertongued, a vertical plane, or cut-off, is arbitrarily used to differentiate the two units in order to avoid repetition of a named unit in a vertical section.

Most formation names consist only of a geographic name and the rank, for instance, Wedron Formation, but formations that are dominantly of one rock type are given a rock name, such as St. Peter Sandstone, and the word formation is omitted. Other units given rock names also include the rank, such as Tiskilwa Till Member. Rock names are capitalized only in the rock-stratigraphic classification.

In time-stratigraphic classification the rocks are classified according to age, or time of deposition, and the units are bounded by time planes that represent a spe-

Fig. 5 - Columnar section of the rock strata in the Chicago area. Abbreviations: Alex.-Alexandrian; Burl.-Burlington; Cin.-Cincinnatian; Desm.-Desmoinesian; Dev.-Devonian; Ed.-Edenian; Fran.-Franconian; Kind.-Kinderhookian; May.- Maysvillian; Miss.-Mississippian; Penn.-Pennsylvanian; Pleis.-Pleistocene; Precam.-Precambrian; Quat.-Quaternary; Rich.-Richmondian; Tremp.-Trempealeauan; Trent.-Trentonian; Up.-Upper; Val.-Valmeyeran.

Time Stratig. System	Time Stratig. Series	Time Stratig. Stage	Rock Stratigraphy Mega-Group	Rock Stratigraphy Group	Rock Stratigraphy Formation	Graphic Column	Thickness (Feet)	Kinds of Rock
QUAT.	PLEIS.				(See fig. 15)		0-350	Till, sand, gravel, silt, clay, peat, marl, loess
PENN.	DESM.			Kewanee	Carbondale		0-125	Shale, sandstone, thin limestone, coal
PENN.	DESM.			Kewanee	Spoon		50-75	As above, but below No. 2 Coal
MISS.	VAL.				Burl.-Keokuk		0-700	Limestone — Only in Des Plaines Disturbance
MISS.	KIND.				Hannibal		0-700	Shale, siltstone — Only in Des Plaines Disturbance
DEV.	UP.				Grassy Creek		0-5	Shale in solution cavities in Silurian
SILURIAN	NIAGARAN		Hunton		Racine		0-300	Dolomite, pure in reefs; mostly silty, argillaceous, cherty between reefs
SILURIAN	NIAGARAN		Hunton		Waukesha		0-30	Dolomite, even bedded, slightly silty
SILURIAN	NIAGARAN		Hunton		Joliet		40-60	Dolomite, shaly and red at base; white, silty, cherty above; pure at top
SILURIAN	ALEX.		Hunton		Kankakee		20-45	Dolomite; thin beds; green shale partings
SILURIAN	ALEX.		Hunton		Edgewood		0-100	Dolomite, cherty, shaly at base where thick
ORDOVICIAN	CIN.	RICH.	Hunton	Maquoketa	Neda		0-15	Oolite and shale, red
ORDOVICIAN	CIN.	RICH.	Hunton	Maquoketa	Brainard		0-100	Shale, dolomitic, greenish gray
ORDOVICIAN	CIN.	RICH.	Hunton	Maquoketa	Ft. Atkinson		5-50	Dolomite, green shale, coarse limestone
ORDOVICIAN	CIN.	MAY. / ED.	Hunton	Maquoketa	Scales		90-120	Shale, dolomitic, gray, brown, black
ORDOVICIAN	CHAMPLAINIAN	TRENT.	Ottawa	Galena	Wise Lake		170-210	Dolomite, buff, pure
ORDOVICIAN	CHAMPLAINIAN	TRENT.	Ottawa	Galena	Dunleith		170-210	Dolomite, pure to slightly shaly; locally limestone
ORDOVICIAN	CHAMPLAINIAN	TRENT.	Ottawa	Galena	Guttenberg		0-15	Dolomite; red specks and shale partings
ORDOVICIAN	CHAMPLAINIAN	BLACKRIVERAN	Ottawa	Platteville	Nachusa		0-50	Dolomite and limestone, pure, massive
ORDOVICIAN	CHAMPLAINIAN	BLACKRIVERAN	Ottawa	Platteville	Grand Detour		20-40	Dolomite and limestone; medium beds
ORDOVICIAN	CHAMPLAINIAN	BLACKRIVERAN	Ottawa	Platteville	Mifflin		20-50	Dolomite and limestone, shaly, thin beds
ORDOVICIAN	CHAMPLAINIAN	BLACKRIVERAN	Ottawa	Platteville	Pecatonica		20-50	Dolomite, pure, thick beds
ORDOVICIAN	CHAMPLAINIAN	BLACKRIVERAN	Ottawa	Ancell	Glenwood		0-80	Sandstone and dolomite, silty; green shale
ORDOVICIAN	CHAMPLAINIAN	BLACKRIVERAN	Ottawa	Ancell	St. Peter		100-600	Sandstone, medium and fine grained; well rounded grains; chert rubble at base
ORDOVICIAN	CANADIAN		Knox	Prairie du Chien	Shakopee		0-70	Dolomite, sandy; oolitic chert; algal mounds
ORDOVICIAN	CANADIAN		Knox	Prairie du Chien	New Richmond		0-35	Sandstone, fine to coarse
ORDOVICIAN	CANADIAN		Knox	Prairie du Chien	Oneota		190-250	Dolomite, pure, coarse grained; oolitic chert
ORDOVICIAN	CANADIAN		Knox	Prairie du Chien	Gunter		0-15	Sandstone, dolomitic
CAMBRIAN	CROIXAN	TREMP.	Knox		Eminence		50-150	Dolomite, sandy
CAMBRIAN	CROIXAN	TREMP.	Knox		Potosi		90-220	Dolomite; drusy quartz in vugs
CAMBRIAN	CROIXAN	FRAN.	Knox		Franconia		50-200	Sandstone, glauconitic; dolomite; shale
CAMBRIAN	CROIXAN	FRAN.	Knox		Ironton		80-130	Sandstone, partly dolomitic, medium grained
CAMBRIAN	CROIXAN	DRESBACHIAN	Knox		Galesville		10-100	Sandstone, fine grained
CAMBRIAN	CROIXAN	DRESBACHIAN	Knox / Potsdam		Eau Claire		370-570	Siltstone, dolomite, sandstone and shale, glauconitic
CAMBRIAN	CROIXAN	DRESBACHIAN	Potsdam		Mt. Simon		1200-2900	Sandstone, fine to coarse; quartz pebbles in some beds
PRE-CAM.								Granite

cific moment in time. The time planes chosen for boundaries of time-stratigraphic units are based on a specific reference section, called a type section, and are placed at a position where there is a significant and traceable change in the rocks. Most major time boundaries are at the beginning or end of a sequence of rocks in which a particular fossil, or group of fossils, is found, and fossils are the principal means by which time planes are traced. In strata that generally lack fossils, other criteria are used, such as soils in the Pleistocene System. Except in their type sections, time planes do not necessarily coincide, in fact, commonly do not coincide, with the boundaries of rock-stratigraphic or other units. The fundamental unit of time-stratigraphy is called a *system*. Groups of systems are called *erathems*, and successively smaller subdivisions of systems are called *series*, *stages*, and *substages*.

The time-stratigraphic classification serves as the basis for the geologic time classification, which therefore is not an independent classification. The interval of time during which a system of rocks was deposited is called a *period*. An erathem was deposited during an *era*, a series during an *epoch*, and a stage during an *age*. A substage has no formal geologic time name. The same geographic names are used in both classifications and they are distinguished from the geographic names in all other classifications by having adjectival endings (Silurian System, Silurian Period). In the Devonian System, Upper, Middle, and Lower Devonian Series are formal units and therefore are capitalized. In the other systems, the series have geographic names, and upper, middle, and lower are used only in informal names and are not capitalized.

The major geologic time subdivisions and the estimated ages of their boundaries (after Arthur Holmes and others) are as follows:

Era	Period	Age in millions of years
Cenozoic	Quaternary	
		2–3
	Tertiary*	
		65
Mesozoic	Cretaceous*	
		136
	Jurassic*	
		190–195
	Triassic*	
		225
Paleozoic	Permian*	
		280
	Pennsylvanian	
	Mississippian	
		345
	Devonian	
		395
	Silurian	
		430–440
	Ordovician	
		500
	Cambrian	
		570
Precambrian		

*No deposits recognized in the Chicago area.

The morphostratigraphic classification is used to differentiate units of rocks that have a distinctive form on the present landscape and occur in stratigraphic succession. The moraines deposited by successive stands of glaciers are the principal basis for morphostratigraphic classification in the Chicago area (pl. 1; fig. 15). All the deposits related to the glacier that built a moraine, including the glacial outwash, kames, eskers, lake sediments, and the groundmoraine, even where buried by younger glacial deposits, are included in a unit called a *drift*. Because most moraines result from a temporary stand of the ice front after an interval of advance and before an interval of retreat, the drifts ideally form overlapping, shingle-like sheets, but in many places the older drifts were intensely eroded where overridden by younger glaciers.

The term drift, when used in formal names (Marseilles Drift), is capitalized to differentiate it from the general usage of the term for all the glacial deposits within the glaciated region. In the general usage, drift does not include loess on the glacial deposits or outwash outside the glaciated region.

Another type of morphostratigraphic unit is the alluvial terrace, which includes all remnants of deposits laid down during a particular episode of valley filling. Although terraces occur at several levels along the major rivers in the Chicago area, they have not been formally named, pending more detailed correlations.

The cyclical classification is used to show the repetition of a distinctive sequence of rocks, particularly rocks of Pennsylvanian age (Kosanke et al., 1960). Each unit, called a *cyclothem*, generally consists of basal sandstone overlain in succession by gray shale, limestone, underclay, coal, gray shale, black shale, limestone, and gray shale. Most cyclothems have some of these units missing over wide areas. The sediments in each cyclothem up to the black shale are generally nonmarine or brackish-water deposits, whereas the black shale and overlying sediments in the cycle are marine. The cyclical classification, therefore, is useful in the study of the successive advances and retreats of the Pennsylvanian seas. The distinctive units of the cyclothems are helpful in mapping the economically important coals, underclays, shales, and limestones.

The soil-stratigraphic classification is based on the usefulness of soils as widespread markers, or key beds, in the glacial deposits. The soils indicate significant unconformities, and nine units given the formal name *soil* are named in Illinois (Willman and Frye, 1970). In the Chicago area only the Wisconsinan Farmdale Soil and the soil now forming on the present surface, called the Modern Soil, are present. The older, interglacial soils have been extensively eroded, but they may be encountered in drill holes in some of the deeper bedrock valleys.

The major unconformities in the rock column mark intervals of widespread erosion and, therefore, an interruption in deposition. The strata between the most extensive unconformities are stratigraphic units called *sequences* (Sloss, 1963). Because of differences in the depth of erosion, the age of the beds missing along the unconformities varies greatly, and the boundaries of the sequences cut across both rock- and time-stratigraphic boundaries (Swann and Willman, 1961).

Both the geographic name and the classification name of formal stratigraphic units are capitalized, as in Joliet Formation, Pleistocene Series, Marseilles Drift. The stratigraphic classification to which a unit belongs can always be determined from its name. For example, the Joliet Formation is a rock-stratigraphic unit, the Pleistocene Series is a time-stratigraphic unit, and the Marseilles Drift is a morphostratigraphic unit.

Because the classification of a unit, and therefore its meaning, can be identified from the name, the names are freely intermixed in stratigraphic descriptions and in discussions of geologic history. This introduces an apparent complexity that is resolved by familiarity with the classifications and by recognition of their complete independence. For example, reference to the Wisconsinan Henry Formation means

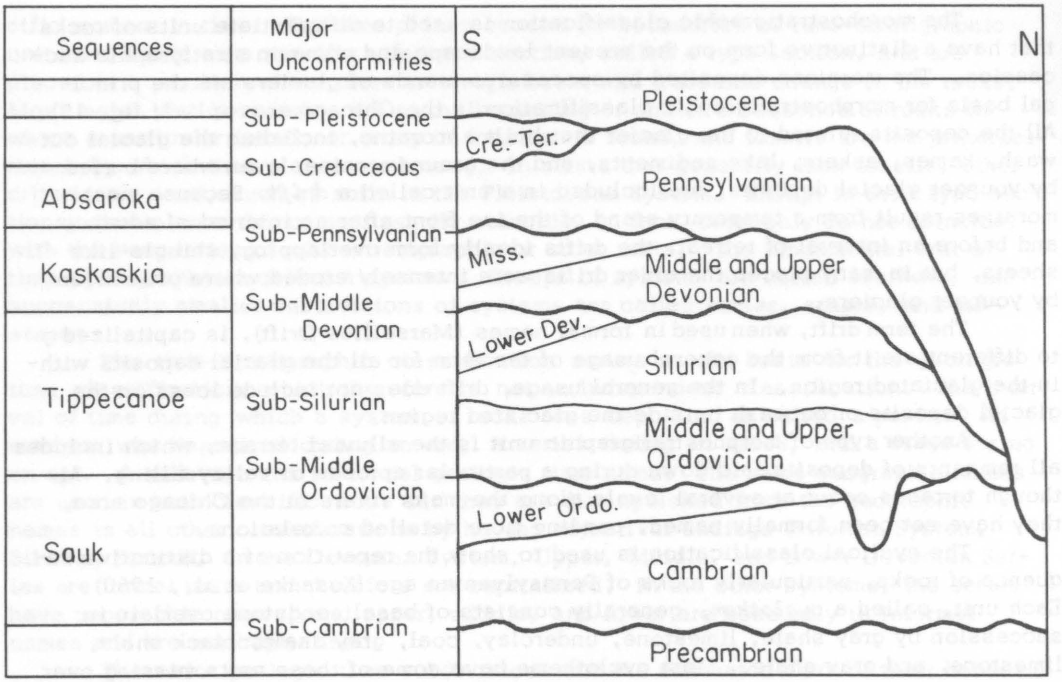


Fig. 6 - Diagrammatic cross section from southern to northern Illinois showing major unconformities and named sequences.

that the Henry Formation is Wisconsinan in age, but the Henry Formation is a rock-stratigraphic unit, not a subdivision of the Wisconsinan Stage. It is differentiated from other formations because of its composition and not because of its age.

STRATIGRAPHIC RELATIONS

Most of the stratigraphic units in the Chicago area have a conformable relation, that is, no significant interruptions in deposition took place. Even though the composition of the sediment changes at the contact between the units, deposition was essentially continuous. At many contacts, however, the lower unit was partly or completely eroded before the overlying sediment was deposited. Contacts where deposition was interrupted and beds are missing are unconformities.

Where the beds above and below an unconformity are essentially parallel, the unconformity is called a disconformity, and where the lower beds were tilted before overlying beds were deposited, the contact is called an angular unconformity. The contact between the Silurian and Ordovician rocks in the Chicago area is a disconformity, whereas the Silurian and Pennsylvanian rocks dip slightly in opposite directions and the contact between them is an angular unconformity.

Minor unconformities that are of limited extent and represent no great amount of erosion occur between some units, particularly the units differentiated in the glacial deposits. Sharp, undulating contacts between and within many units may be depositional features; they are not unconformities unless there is evidence that beds are missing.

The major unconformities, as previously noted, are used to differentiate units called sequences. A diagrammatic cross section from southern to northern Illinois (fig. 6) shows the stratigraphic relations of the sequences, although it distorts their thicknesses and dips. It reveals the major tectonic events (vertical or tilting movements) and the erosional events in the geologic history of the area. These events are summarized below:

The oldest and deepest rocks in the Chicago area are the Precambrian rocks, which were metamorphosed by heat and pressure at great depths in the crust of the earth. They were intruded by masses of molten rock that cooled slowly, forming granite; later they were uplifted and deeply eroded before late Cambrian time. The sub-Cambrian unconformity represents an interval of time longer than all the time since the beginning of the Cambrian Period. This unconformity is 3,000 to 5,000 feet below the surface in the Chicago area. It is a generally flat surface, but hills of harder rock are locally prominent where the unconformity is exposed in Wisconsin and Missouri (fig. 1).

Only a minor unconformity separates the Cambrian and lower Ordovician (Canadian) rocks that compose the Sauk Sequence. After deposition of the lower Ordovician rocks, the tectonic movements that disturbed major areas in the eastern part of the continent caused uplift, warping, and erosion in the Chicago area. As a result the basal middle Ordovician (Champlainian) St. Peter Sandstone truncates the lower Ordovician rocks and rests directly on Cambrian strata in the central and northern parts of the area (fig. 6). The sub-middle Ordovician unconformity is a rough surface, locally characterized by sinkholes, and it has a prominent escarpment at the margin of the lower Ordovician dolomites (Buschbach, 1961). As lower Ordovician rocks are present again north of the Chicago area, the uplift may represent an early movement along the Kankakee Arch. The unconformity is exposed in the La Salle and Ottawa areas to the west, but it is 300 to 1,000 feet deep in the Chicago area.

The next younger major unconformity is at the base of the Middle Devonian rocks, where it forms the upper boundary for the middle and upper Ordovician, Silurian, and Lower Devonian sediments that compose the Tippecanoe Sequence. Although a widespread but minor unconformity occurs at the base of the upper Ordovician (Cincinnatian) rocks, the surface of the unconformity is nearly flat and only slightly truncates the middle Ordovician rocks.

The end of Ordovician time was marked by uplift, and valleys were cut as much as 150 feet deep in the shale of the upper Ordovician Maquoketa Group. The valleys were filled with early Silurian sediments, but between the valleys there is only slight evidence of unconformity. There is no significant variation in the dip of the rocks, and this unconformity, also, is not comparable to those bounding the Tippecanoe Sequence. In Illinois there is no evidence of an unconformity between Silurian and Lower Devonian rocks in the deep part of the Illinois Basin, and sedimentation apparently was continuous.

The sub-Middle Devonian unconformity at the top of the Tippecanoe Sequence is related to an interval of active tectonic movements in the Appalachian region. As a result of tilting and erosion, the Middle Devonian sediments truncate the Lower Devonian, the upper Silurian (Cayugan), and part of the middle Silurian (Niagaran) rocks north of central Illinois (fig. 6). On local areas of greater uplift, the Middle Devonian strata completely truncate the Silurian and rest on upper Ordovician rocks. In the Chicago area the Middle Devonian strata have been entirely eroded, but the position of the basal unconformity may not have been far above the youngest Silurian in the region. Overlapping Upper Devonian black shale has been found in local pockets on top of the Silurian dolomite and is probably present in the Des Plaines Disturbance. Teeth of Devonian or Mississippian sharks have been found in crevices in the dolomite (fig. 11B). Although Middle Devonian rocks occur both north and south of the Chicago area, Upper Devonian and Mississippian age rocks rest directly on the Silurian in the fault blocks of the Des Plaines Disturbance (fig. 13), and the Chicago area either remained above sea level following the sub-Middle Devonian uplift, or the Middle Devonian rocks were deposited and truncated before or during Upper Devonian time. In either case, the relations appear to result from an uplift of the Kankakee Arch.

The Middle and Upper Devonian and the Mississippian rocks compose the Kaskaskia Sequence, which is bounded at the top by the prominent sub-Pennsylvanian unconformity. A minor unconformity separates the Middle Devonian from the Upper Devonian rocks, but in Illinois there was essentially continuous deposition from Devonian to Mississippian time.

The sub-Pennsylvanian unconformity resulted from regional uplift and upward warping of the Kankakee Arch and other anticlinal structures in Illinois. These movements continued into early Pennsylvanian time and caused deep erosion, during which older rocks were removed from wide areas in the northern part of the state. Subsequent depression of the Illinois Basin (fig. 1) resulted in deposition of Pennsylvanian sediments that northward overlap Mississippian, Devonian, Silurian, and part of the Ordovician rocks (fig. 6). In the southwest corner of the Chicago area, Pennsylvanian strata rest on Ordovician and Silurian rocks (fig. 9), but elsewhere in the area Pennsylvanian rocks generally have been eroded. The local preservation of Mississippian strata in the Des Plaines Disturbance (fig. 13) indicates that these rocks formerly covered the entire area but were eroded from the Kankakee Arch during the development of the sub-Pennsylvanian unconformity.

The Absaroka Sequence consists of the sediments between the sub-Pennsylvanian and sub-Cretaceous unconformites. In Illinois these sediments are all of Pennsylvanian age. Although no major unconformities occur within the Pennsylvanian System in Illinois, the northward overlap results in restriction of earliest Pennsylvanian sediments to southern Illinois. Pennsylvanian sediments formerly covered the entire Chicago area, as is shown by their preservation in the Des Plaines Disturbance. Minor unconformities occur at the base of some of the Pennsylvanian sandstones.

The sub-Cretaceous unconformity represents a long interval of time, from the early part of late Pennsylvanian to late Cretaceous time. At the end of the Paleozoic Era, the Chicago area was uplifted and warped during the major tectonic movements that folded and faulted the formations in the Appalachian Mountains region. The Kankakee Arch was again uplifted and the Pennsylvanian sediments were eroded from most of the Chicago area. There is no evidence that sediment accumulated during this long interval, and consequently no record of the intervals of uplift and depression that may well have taken place. In extreme southern Illinois, Cretaceous and Tertiary sediments rest on warped, faulted, and truncated Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian rocks, and their preservation results from downwarping of the coastal plain. In western Illinois, Cretaceous sediments rest on a relatively flat surface that truncates Mississippian and Pennsylvanian strata. In more distant areas the Cretaceous and Tertiary rocks are divided into two or three sequences (Sloss, 1963).

In Illinois the sub-Pleistocene unconformity truncates all the Tertiary, Cretaceous, and Paleozoic rocks down to the upper Cambrian (fig. 6). This unconformity is the bedrock surface (fig. 9). Although all of this surface has been repeatedly eroded, and in places deeply channeled, during Pleistocene time, it probably is not far (perhaps 100 feet) below the former position of the sub-Cretaceous unconformity. The sub-Pennsylvanian and sub-Middle Devonian unconformities converge on the Kankakee Arch, and these surfaces also may not have been far above the present surface.

FOSSILS

Fossils are common in many of the rock formations in the Chicago area (figs. 7 and 8) and are used to determine the ages of the rocks and the environments in which the rocks were deposited. A great variety of fossil marine invertebrates are common in the Ordovician, Silurian, and Pennsylvanian rocks; plants, insects, and vertebrates are found in the Pennsylvanian rocks; and plants, invertebrates, and vertebrates occur in the Pleistocene rocks (Collinson, 1959).

In the Ordovician rocks, the fauna of the Galena Group in the Chicago area includes brachiopods, gastropods, cephalopods, and sponges. The fossils have not been described in detail, but a few are listed by Culver (1922). A large fauna of invertebrates, mostly brachiopods and bryozoans, has been described from the Fort Atkinson Limestone near Wilmington, Minooka, and Oswego (Savage, 1925).

In the Silurian rocks, a large and varied fauna of brachiopods, corals, and trilobites has been described from exposures of the Kankakee and Joliet Formations in quarries at Joliet (Savage, 1926). The lower part of the Joliet has a distinctive fauna of arenaceous foraminifera. The Waukesha Formation contains trilobites, crinoids, and cephalopods, and it is widely known for the abundant and well preserved trilobites that have been taken from spoil heaps and quarries along the Chicago Sanitary Ship Canal northeast of Lemont. The reefs of the Racine Formation have a large fauna that includes corals, stromatoporoids, crinoids, brachiopods, and trilobites (Lowenstam, 1950; Ingels, 1963), whereas the interreef strata have a sparser fauna of crinoids, trilobites, sponges, corals, and brachiopods (Lowenstam, 1948).

In the Pennsylvanian rocks the marine limestones and shales contain brachiopods, gastropods, pelecypods, and corals. The most widely known fossils of the Chicago area are the "Mazon Creek fossils" that occur in ironstone (siderite) concretions in the Francis Creek Shale Member of the Pennsylvanian Carbondale Formation (Noé, 1925; Richardson, 1956; Collinson and Skartvedt, 1960). For more than a century the seed ferns, ferns, club mosses, scale trees, insects, amphibians, and reptiles from this locality have graced museums all over the world. In recent years, an equally famous but predominantly marine assemblage of soft-bodied animals that has become equally famous has been found in a strip mine near Essex, just south of the Chicago area. It is called the "Essex concretion fauna" (Johnson and Richardson, 1970). The fauna contains hundreds of species, including jellyfish, shrimp, sharks, coelacanth fish, crabs, insects, soft-bodied worms, lampreys, lung fish, and amphibians.

The Pleistocene formations in the Chicago area are fossiliferous in places. The postglacial lake and swamp deposits contain wood, swamp vegetation, pollen, spores, gastropods, and pelecypods. Vertebrates, especially mastodons and mammoths, are occasionally found in the swamp deposits.

Fossils are also found in the glacial till — largely Paleozoic invertebrate fossils eroded by the glaciers from the local bedrock and from rock formations north and northeast of Illinois. Such fossils do not date the rocks in which they now occur, but they are useful in determining the directions of flow of the glaciers.

BEDROCK STRATIGRAPHY

PRECAMBRIAN ROCKS

The oldest rocks of the Earth are the Precambrian rocks (fig. 5), which are also called "the crystallines" or "the basement rocks." Only one drill hole has penetrated to the Precambrian in the Chicago area. It was drilled 6 miles west of Joliet in the Plainfield Quadrangle (SW$\frac{1}{4}$ NE$\frac{1}{4}$ NW$\frac{1}{4}$ Sec. 20, T. 35 N., R. 9 E., Will Co.) and encountered red granite at a depth of 4,222 feet (Bradbury and Atherton, 1965). If the Precambrian surface has the same dip as the top of the Glenwood-St. Peter Sandstone (fig. 12), it ranges in depth from 2,500 to 3,000 feet along the north boundary line of the area to 5,000 to 5,500 feet deep along the south boundary. It is approximately 4,500 feet deep in the area of the Chicago Loop (Buschbach, 1964). Age determinations of Precambrian rocks in nearby areas indicate that the uppermost, or youngest, Precambrian rocks in the Chicago area are 1 to 1.5 billion years old. Fragments of Precambrian igneous and metamorphic rocks transported by glaciers from Canada are abundant in the glacial drift.

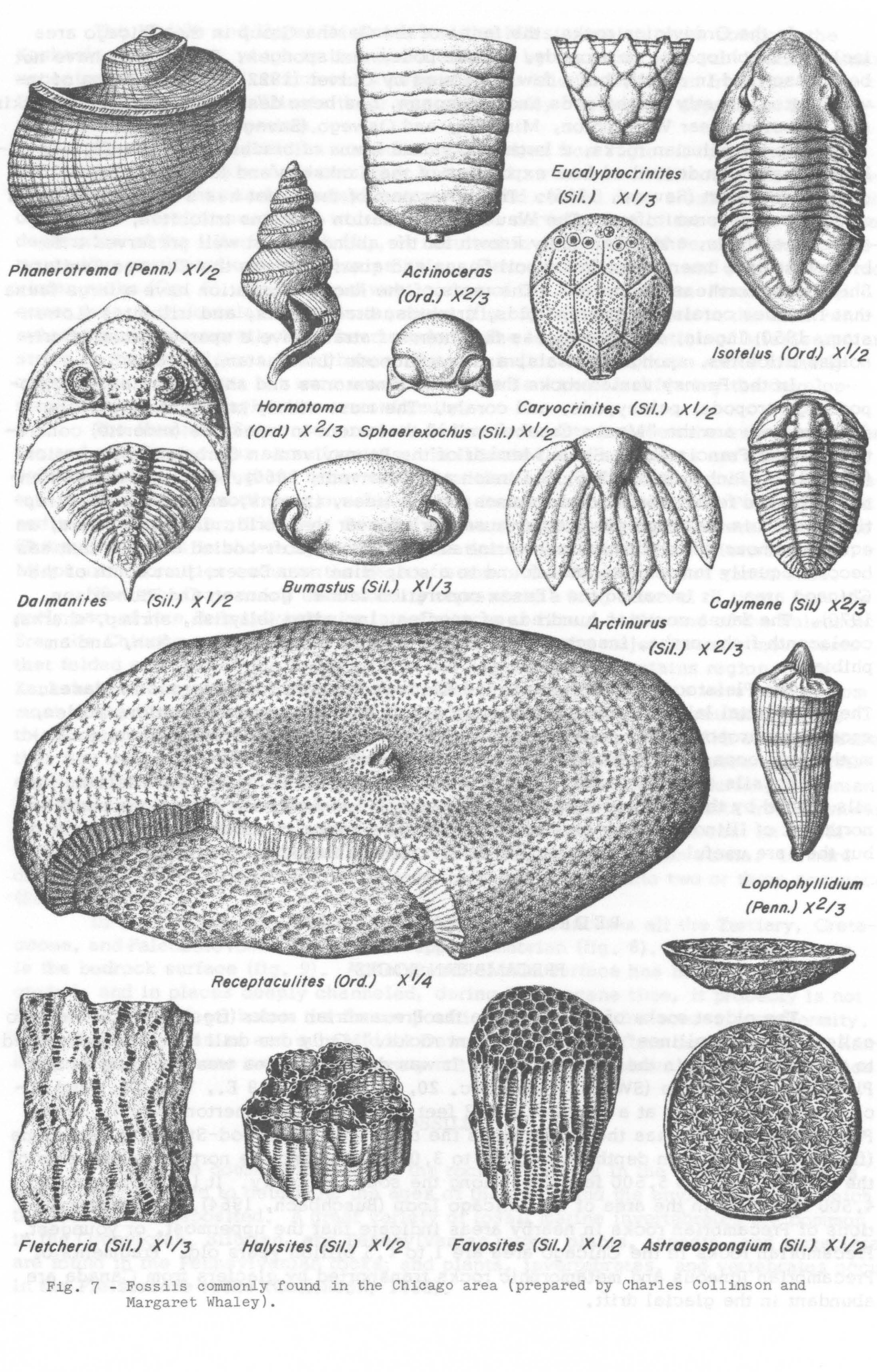


Fig. 7 - Fossils commonly found in the Chicago area (prepared by Charles Collinson and Margaret Whaley).

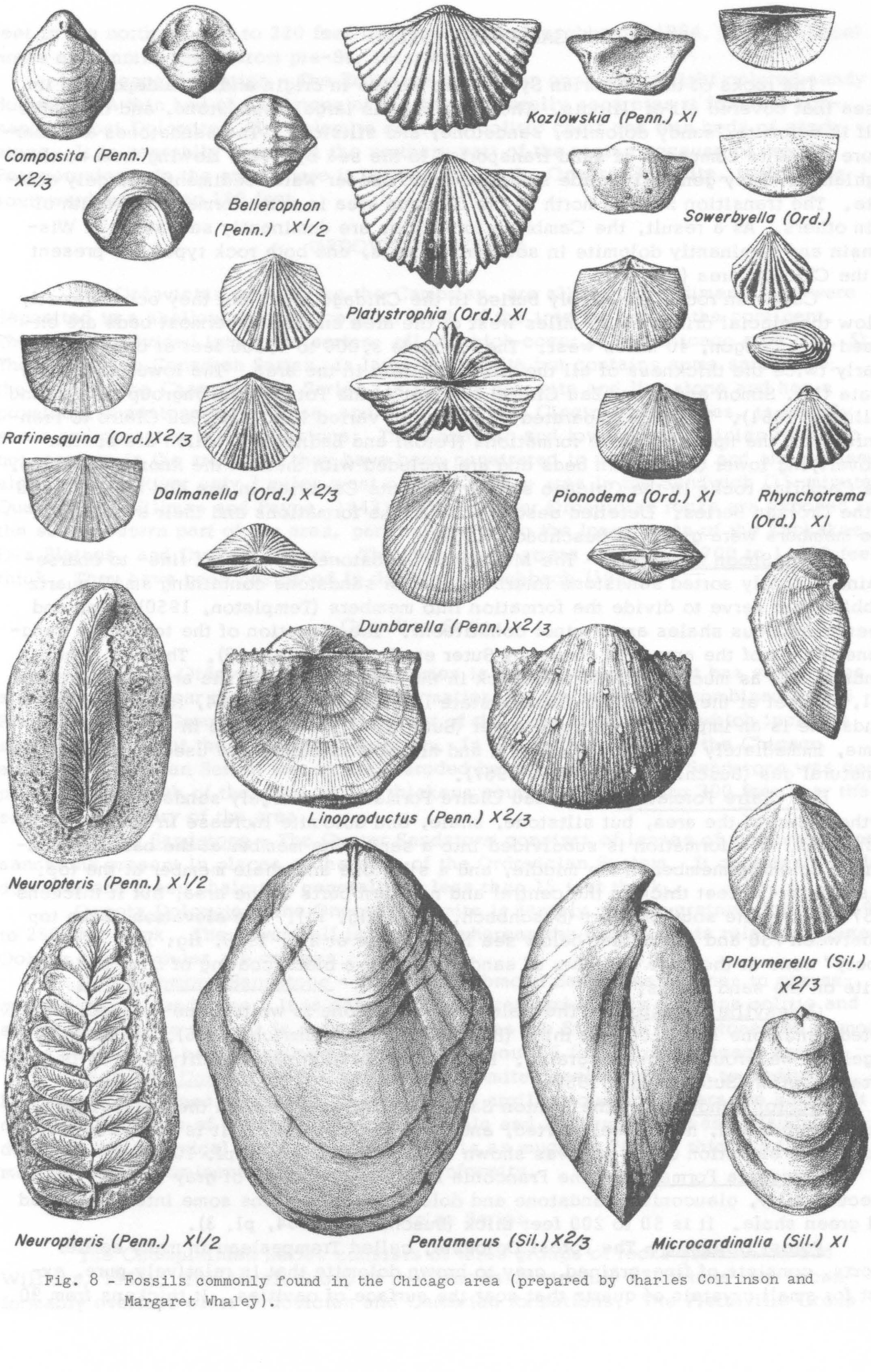


Fig. 8 - Fossils commonly found in the Chicago area (prepared by Charles Collinson and Margaret Whaley).

CAMBRIAN SYSTEM

The rocks of the Cambrian System are marine in origin and were deposited in a sea that covered all of Illinois. The lower half is largely sandstone, and the upper half is dolomite, sandy dolomite, sandstone, and siltstone. The sandstones are near-shore deposits composed of sand transported to the sea by rivers flowing from northern highlands. They generally grade southward into deeper water sediments, largely dolomite. The transition zone is north of the Chicago area in some formations, south of it in others. As a result, the Cambrian formations are dominantly sandstone in Wisconsin and dominantly dolomite in southern Illinois, and both rock types are present in the Chicago area (fig. 5).

Cambrian rocks are deeply buried in the Chicago area, but they occur directly below the glacial drift only 10 miles west of the area and the uppermost beds are exposed near Oregon, 40 miles west. They include 3,000 to 4,000 feet of deposits, nearly twice the thickness of all the younger strata in the area. The lower sandstone strata (Mt. Simon and lower Eau Claire) are part of the Potsdam Megagroup (Swann and Willman, 1961). They are separated by a zone of varied lithology (Eau Claire to Franconia) from the upper dolomite formations (Potosi and Eminence), which are similar to overlying lower Ordovician beds and are included with them in the Knox Megagroup. The Cambrian rocks in the Chicago area are all late Cambrian in age and are assigned to the Croixan Series. Detailed descriptions of the formations and their subdivision into members were given by Buschbach (1964).

Mt. Simon Sandstone - The Mt. Simon Sandstone consists of fine- to coarse-grained, poorly sorted sandstone interbedded with sandstone containing small quartz pebbles that serve to divide the formation into members (Templeton, 1950). Red and green micaceous shales are a minor constituent. The elevation of the top of the sandstone in part of the area was shown by Suter et al. (1959, fig. 19). The Mt. Simon Sandstone is as much as 2,900 feet thick in the southern part of the area, but it thins to 1,200 feet at the Wisconsin-Illinois state line (Buschbach, 1964, fig. 10). The sandstone is an important source of water (Suter et al., 1959), and in the Herscher Dome, immediately south of the area, it and higher sandstones are used for the storage of natural gas (Buschbach and Bond, 1967).

Eau Claire Formation - The Eau Claire Formation is largely sandstone in the northern part of the area, but siltstone, shale, and dolomite increase in abundance southward. The formation is subdivided into a sandstone member at the base, a glauconitic dolomite member in the middle, and a siltstone and shale member at the top. It is 370 to 450 feet thick in the central and northern parts of the area, but it thickens to 570 feet in the southern part (Buschbach, 1964, fig. 11). The elevation of the top is between 750 and 1,500 feet below sea level (Suter et al., 1959, fig. 19). A "sooty" zone at the base consists of sandstone with a black coating of fine-grained pyrite on the sand grains.

Galesville Sandstone - The Galesville Sandstone is white, fine-grained, well sorted sandstone 10 to 100 feet thick (Buschbach, 1964; Emrich, 1966). It consists largely of well rounded quartz grains. Because of its high permeability it is an important aquifer (Suter et al., 1959).

Ironton Sandstone - The Ironton Sandstone varies more than the Galesville. It is medium grained, not as well sorted, and is in part dolomitic. It is 80 to 130 feet thick. The elevation of the top was shown by Buschbach (1964, pl. 10).

Franconia Formation - The Franconia Formation consists of gray to pink, argillaceous, silty, glauconitic sandstone and dolomite. It contains some interbedded red and green shale. It is 50 to 200 feet thick (Buschbach, 1964, pl. 3).

Potosi Dolomite - The Potosi Dolomite, called Trempealeau in many earlier reports, consists of fine-grained, gray to brown dolomite that is relatively pure, except for small crystals of quartz that coat the surface of cavities. It thickens from 90 feet in the northern part to 220 feet in the southern (Buschbach, 1964, pl. 4). Local areas of thinning result from pre-St. Peter erosion.

Eminence Formation - The Eminence Formation consists of light colored sandy dolomite. A thin bed of sandstone at the base generally separates it from the non-sandy Potosi Dolomite. The dolomite contains oolitic chert and thin beds of sandstone. It is generally absent in the northern part of the region because of pre-St. Peter erosion. In the area where it is overlain by the Oneota Dolomite, it thickens southward from 50 to 150 feet.

ORDOVICIAN SYSTEM

The Ordovician rocks, like the Cambrian, are all marine sediments and were deposited in a shallow sea that covered much of the interior part of the continent. They are subdivided into three series, all of which occur in the Chicago area (fig. 5). The lower, the Canadian Series, is largely dolomite but contains some sandstone; the middle, the Champlainian Series, is largely dolomite and limestone and has a prominent sandstone at the base; and the upper, the Cincinnatian Series, is largely shale and contains some limestone. The Canadian and lower Champlainian rocks do not crop out in the area, but they have been penetrated in many wells and are exposed along the Fox River only 3 miles west of the Chicago area in the Sandwich (15-minute) Quadrangle (Willman and Payne, 1943). The younger Ordovician rocks are exposed in the southwestern part of the area, particularly along the lower parts of the Kankakee, Des Plaines, and Du Page Rivers. The Ordovician strata range from 700 to 1,100 feet thick. They have been described in detail by Buschbach (1964).

Canadian Series

The lower Ordovician Canadian Series is largely dolomite but has sandstones at the base and near the top. The four formations in the series are combined as the Prairie du Chien Group. They are also part of the Knox Megagroup, which includes similar dolomite at the top of the Cambrian. In the northern third of the Chicago area, the Canadian Series was entirely eroded before the St. Peter Sandstone was deposited, but south of there the series thickens southward, reaching 300 feet near the southern boundary of the area.

Gunter Sandstone - The Gunter Sandstone consists of lenses of medium-grained sandstone present in places at the base of the Ordovician System. It contains a little dolomite and green shale and generally is less than 15 feet thick.

Oneota Dolomite - The Oneota Dolomite is largely coarse-grained dolomite 190 to 250 feet thick. The lower half is cherty, whereas the upper half is relatively pure. Oolitic chert nodules are common.

New Richmond Sandstone - The New Richmond Sandstone is fine- to coarse-grained quartz sandstone. It is dolomitic in places and locally contains oolitic and sandy chert at the top. It is not as well sorted as the St. Peter Sandstone and is more cross bedded. It has a maximum thickness of about 35 feet in the Chicago area.

Shakopee Dolomite - The Shakopee Dolomite consists of thin- to medium-bedded, fine-grained dolomite. Some beds are argillaceous and others are sandy. It contains thin beds of sandstone and green shale and lenticular masses of laminated dolomite that are algal reefs. The formation is as much as 70 feet thick. Its top is marked by the prominent sub-St. Peter unconformity.

Champlainian Series

The Champlainian Series consists of three groups of rocks (Templeton and Willman, 1963). The Ancell Group at the base is dominantly sandstone that unconformably overlaps older Ordovician and Cambrian formations. The Platteville Group above consists of slightly shaly and relatively pure limestone and dolomite formations. The Platteville is separated by minor unconformities from the groups above and below. The Galena Group at the top also is dominantly dolomite and limestone, and it contains distinctive red shale partings at the base. Because both are dominantly limestone and dolomite, the two groups are combined in the Ottawa Megagroup.

The oldest rocks well exposed in the Chicago area are in the Galena Group in a quarry at Central, north of Morris. However, a few shallow exposures farther west near Lisbon may be in the older Platteville Group. In a small area near Lisbon the Ancell Group (St. Peter Sandstone) lies directly beneath the glacial drift, and it is the oldest unit on the geologic map of the bedrock surface (fig. 9). The Champlainian Series ranges from 400 to 1,000 feet thick, but it commonly is 500 to 600 feet thick.

Ancell Group

St. Peter Sandstone - The St. Peter Sandstone is white, fine- and medium-grained, well sorted sandstone composed almost entirely of well rounded and frosted grains of quartz. At its base, a distinctive rubble of angular chert embedded in clay is the residue left from solution of the underlying formations. It is widely present, uneven in thickness, and locally as much as 100 feet thick where the formation is thick. Red and green shale also occurs at the base. The formation is commonly 100 to 200 feet thick, but where it fills valleys and sinkholes it is as much as 600 feet thick (Buschbach, 1964, pl. 6).

Glenwood Formation - The Glenwood Formation consists of sandstone, impure dolomite, and shale and is as much as 80 feet thick. In many localities it consists of only a few feet of sandstone, generally coarser grained and more poorly sorted than the St. Peter Sandstone below. The elevation of the top is shown in figure 12.

Platteville Group

Pecatonica Dolomite - The Pecatonica Dolomite consists of brown, relatively pure dolomite. It generally is sandy at the base and is separated by a minor unconformity from the Glenwood below. Locally it grades to pure, very fine-grained limestone. It is 20 to 50 feet thick.

Mifflin Formation - The Mifflin Formation consists of light gray, very fine-grained, thin-bedded limestone or dolomite that contains green or brown shale partings. It is 20 to 50 feet thick.

Grand Detour Formation - The Grand Detour Formation is also fine-grained limestone and dolomite, but it is light brownish gray, has dark gray mottling, is medium-bedded, and has thin red shale partings at the top. It is 20 to 40 feet thick.

Nachusa Formation - The Nachusa Formation consists of relatively pure, medium-grained, brown dolomite or limestone. It is similar to the limestone and dolomite in the overlying Galena Group and not readily separable from it where the basal Galena Guttenberg Formation with its distinctive red shale partings is absent. The Nachusa Formation has a maximum thickness of 50 feet, but it is absent in places. A minor unconformity at the top results in irregular thicknesses and accounts for the absence of the Quimbys Mill Formation, which overlies the Nachusa a short distance west of the Chicago area.

Galena Group

Guttenberg Formation - The Guttenberg Formation consists of brown dolomite, or limestone in places, distinguished by the presence of red speckling or thin, reddish brown shale partings. It locally contains a trace of fine quartz sand. It is as much as 15 feet thick but is absent in places.

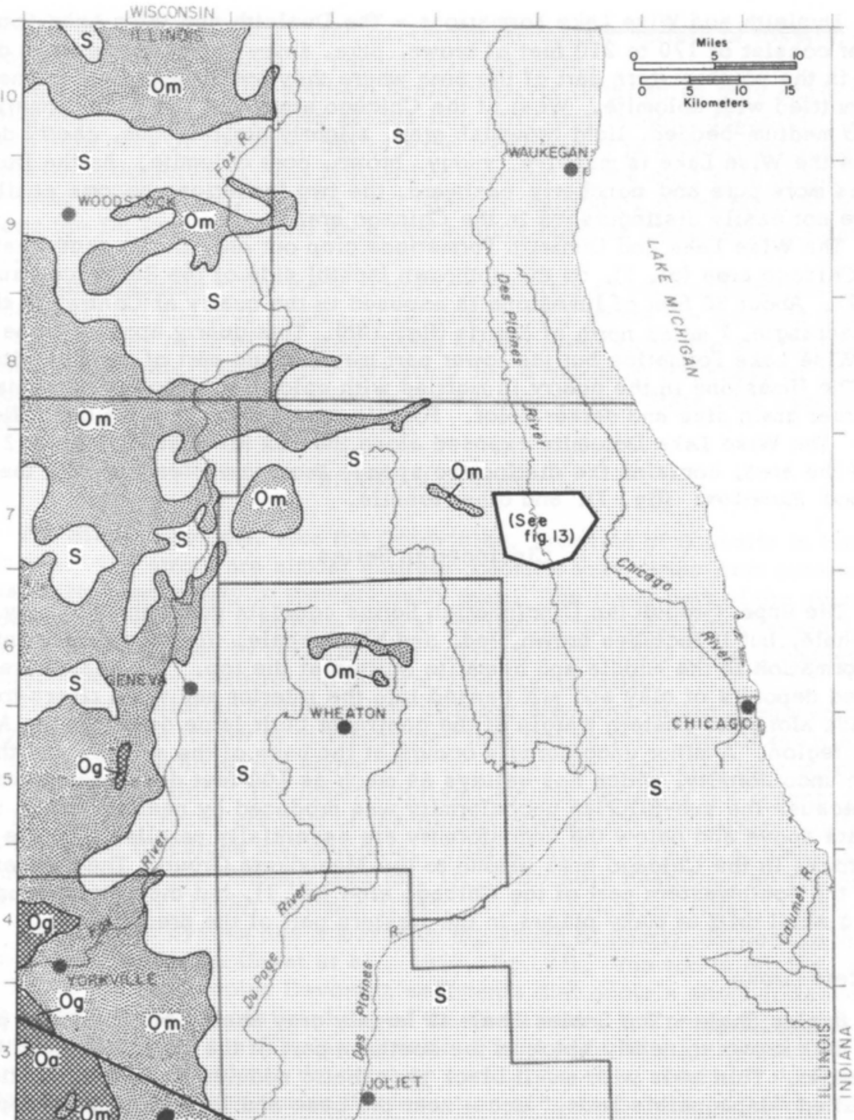


Fig. 9 - Geologic map of the bedrock surface (after Willman and others, 1967).

Dunleith and Wise Lake Formations - The Dunleith and Wise Lake Formations together consist of 170 to 210 feet of brown, pure, fine- to medium-grained dolomite, except in the southwestern part of the area where they are largely fine-grained limestone mottled with dolomite. West of the Chicago area, the Dunleith Formation is thin- to medium-bedded, light brownish gray, slightly argillaceous, cherty dolomite, whereas the Wise Lake is massive, vuggy, brown, pure dolomite. As the Dunleith becomes more pure and noncherty eastward, the two formations become similar, and they are not easily distinguished in the Chicago area.

The Wise Lake and Dunleith Formations crop out only in the southwestern part of the Chicago area (pl. 1), on the upthrown (south) side of the Sandwich Fault (fig. 12). About 80 feet of limestone is exposed in the quarry at Central in the Lisbon Quadrangle, 7 miles north of Morris (fig. 10B). This quarry appears to be largely in the Wise Lake Formation but the lower part may include part of the Dunleith Formation. The limestone in the quarry is mottled with dolomite which is recognized by its coarser grain size and darker color. Fossils are common in some beds (figs. 7 and 8). The Wise Lake Dolomite exposed along the Fox River at Millhurst, 2 miles west of the area, contains the distinctive sponge *Receptaculites* (fig. 7), the large gastropod *Hormotoma* (fig. 7), and other fossils.

Cincinnatian Series

The upper Ordovician Cincinnatian Series consists dominantly of gray and green shale, but it includes brown, red, and black shale. It has a persistent limestone formation in the middle and hematite oolites at the top. The shales are consolidated deposits of clay and silt carried into the interior sea when rivers from highlands along the eastern margin of the continent built large deltas in the Appalachian region. A minor unconformity occurs at the base of the series, and the sub-Silurian unconformity, which has valleys as much as 100 feet deep, occurs at the top. Because the sub-Silurian unconformity was produced by nearly vertical uplift, the strata above and below the unconformity are essentially parallel. All the Cincinnatian rocks in the Chicago area belong to the Maquoketa Group. They are exposed only in the southwestern part of the Chicago area (pl. 1), but they directly underlie the glacial drift at many places in the western part of the area (fig. 9).

Maquoketa Group

Scales Shale - The Scales Shale is largely gray shale, but the lower part is locally dark brown to nearly black in the southern part of the area. Much of the shale is dolomitic. Thin beds with small black phosphatic nodules and small pyritic fossils, called "depauperate beds," occur near the base and locally near the top. The trilobite *Isotelus* (fig. 7) is common in the shale between the upper depauperate bed and the overlying Fort Atkinson Limestone. The lower depauperate bed is not exposed in the area but is commonly encountered in drill holes. The upper bed and the *Isotelus*-bearing shale were formerly exposed in the H. I Green Company clay pit at Goose Lake, 4 miles north of Coal City (Coal City Quad.). The Scales Shale is 90 to 120 feet thick. There are few outcrops, and these expose only a few feet of the shale.

Fort Atkinson Limestone - The Fort Atkinson Limestone varies in composition. It consists of gray, fossiliferous, shaly limestone in outcrops along the Kankakee River near Wilmington (Wilmington Quad.); tan and pink, crinoidal, coarsely crystalline limestone (fig. 10C) overlying fine-grained dolomite near the Dresden Island lock and dam (Minooka Quad.) and north of Millsdale (Channahon Quad.); and mostly fine-grained dolomite interbedded with shale elsewhere. It is exposed only along the Kankakee River and the lower parts of the Des Plaines and Du Page Rivers. The formation is 20 to 30 feet thick in the outcrop area, but in drill holes elsewhere it ranges from 5 to 50 feet thick. The limestone contains a variety of fossils, with the brachiopod *Rafinesquina* (fig. 8) particularly abundant.

Brainard Shale - The Brainard Shale consists of greenish gray shale that is generally dolomitic and in places grades into silty argillaceous dolomite. It has a maximum thickness of 100 feet, but in some localities it is entirely truncated by the sub-Silurian unconformity. The Brainard is exposed on the east side of the Des Plaines Valley along the Atchison, Topeka, and Santa Fe Railroad 2 miles north of Millsdale and along the Du Page River and Rock Run 2 miles north of Channahon (Channahon Quad.).

Neda Formation - The Neda Formation consists of beds of hematite oolites interbedded with red and gray shale. It is present only where the Brainard Shale is thick, and in many parts of the area it was eroded away along the sub-Silurian unconformity (Workman, 1950). The formation has a maximum thickness of 15 feet. It is exposed along the Kankakee River in the Kankakee River State Park campground about 2 miles south of the Chicago area.

SILURIAN SYSTEM

The Silurian System, like the Ordovician, consists of deposits in the shallow interior sea. The strata are almost entirely dolomite that varies from extremely argillaceous, silty, and cherty to exceptionally pure. The lower part of the system consists of distinctive units that have lateral continuity throughout the region. The upper part is characterized by reefs of pure dolomite surrounded by well bedded, slightly argillaceous to very impure and generally cherty dolomite.

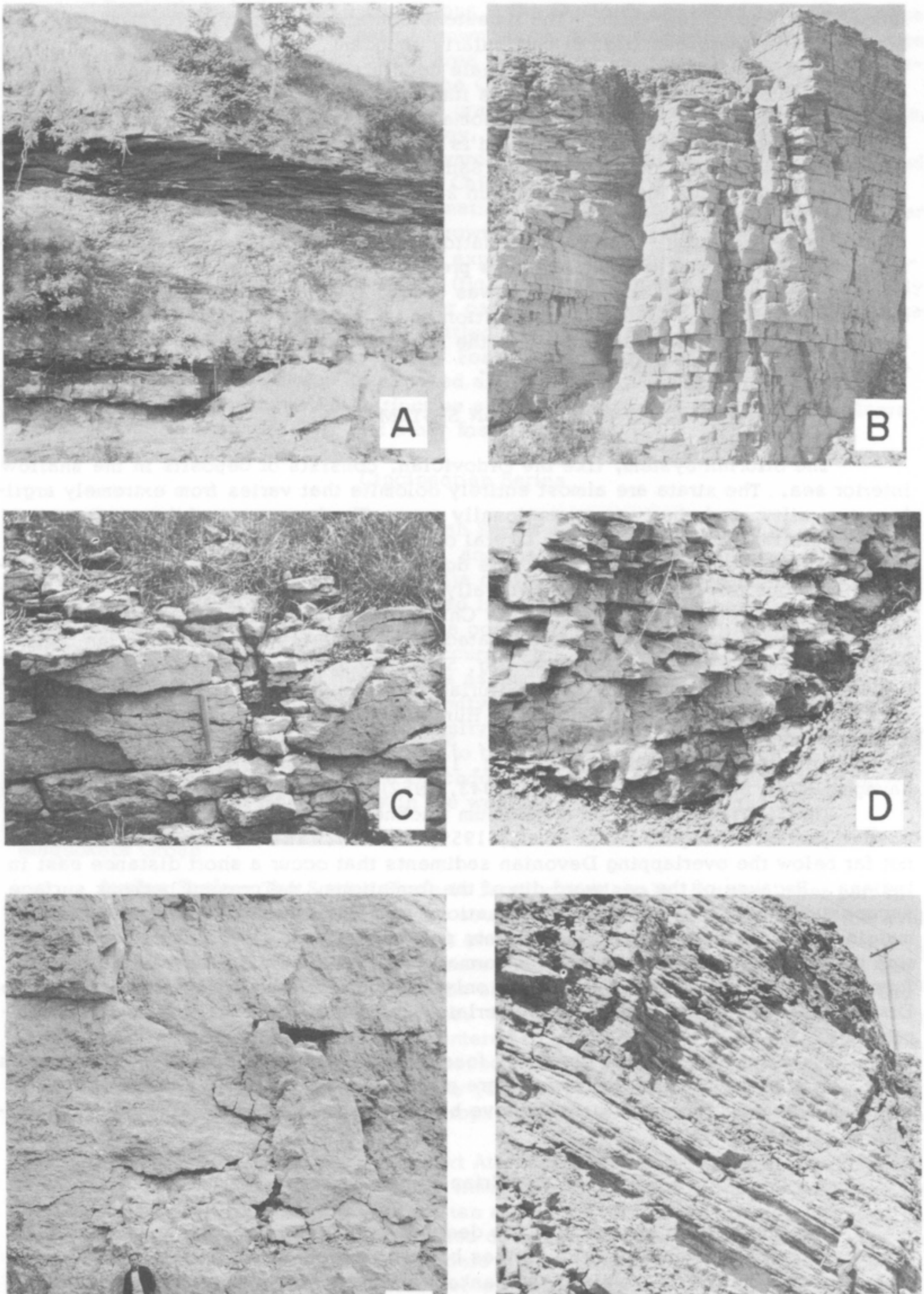
The entire Silurian System in the Chicago area was called Niagaran dolomite in early reports, but it now is differentiated into two series — the Alexandrian Series below and the Niagaran Series above (fig. 5). They are separated by a minor interruption in sedimentation. The upper Silurian Cayugan Series is not present in the area. The Silurian rocks are part of the Hunton Megagroup that farther south includes Devonian limestone and dolomite. Silurian strata crop out at many places in the southern half of the Chicago area (pl. 1). They were described by Fisher (1925); Savage (1926); Bretz (1939); Willman (1943, 1962); Lowenstam (1948, 1949); and others.

The Silurian System has a maximum thickness of nearly 500 feet in the southeastern part of the region (Suter et al., 1959, fig. 27). The top is eroded, but it is not far below the overlapping Devonian sediments that occur a short distance east in Indiana. Because of the eastward dip of the formations, the present bedrock surface successively truncates the Silurian formations from Lake Michigan westward to the margin of the Silurian rocks in the western part of the area. Much of this truncation was probably accomplished during the formation of the sub-Middle Devonian unconformity, because the Silurian strata are only 230 feet or less thick in the Des Plaines Disturbance (fig. 13) where they are overlain by shale of Upper Devonian-Mississippian age.

The Silurian rocks are generally fossiliferous, those in the reefs abundantly so (figs. 7 and 8). However, the fossils are preserved only as casts and molds. The original calcite and aragonite shells have been largely destroyed during recrystallization to dolomite.

Alexandrian Series

The Alexandrian strata filled the deep channels eroded in the underlying Maquoketa Group and overtopped the divides between the channels. Alexandrian strata vary from only 20 feet thick along the Kankakee River to as much as 150 feet in the deeper channels in the sub-Silurian surface.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Edgewood Dolomite - The Edgewood Dolomite changes progressively from highly argillaceous, dark gray dolomite in the lower part of the channels in the sub-Silurian surface to only slightly argillaceous, light brownish gray dolomite in the upper 25 feet. The upper zone is characterized by white chert in beds, lenses, and nodules. The formation has a maximum thickness of 100 feet. Where it thins over the divides between the channels, only the upper zone is present, and along the Kankakee River the formation is absent locally. The basal part of the thick Edgewood is well exposed along the Atchison, Topeka, and Santa Fe Railroad at the curve 5 miles southwest of Joliet (fig. 10D), and the eastward dip of the beds brings the upper cherty beds to the level of the railroad about a mile northeast of the curve (Channahon Quad.).

Kankakee Dolomite - The Kankakee Dolomite consists of fine- to medium-grained, gray to pinkish gray dolomite in wavy beds 1 to 3 inches thick that are separated by thin partings of green shale (fig. 11C). Chert nodules are locally present but are not abundant. The formation is 40 to 50 feet thick in much of the area, but between Joliet and the Kankakee River southeast of Wilmington it thins to 20 feet.

The Kankakee Dolomite is well exposed in its type locality along the Kankakee River, just south of the area (Herscher 15-minute Quad.); in the Des Plaines Valley bluffs and quarries on the southwest side of Joliet (Channahon, Elwood and Joliet Quads.); in deep quarries at Elmhurst (Elmhurst Quad.), Hillside (Hinsdale Quad.), and the Stearns quarry at 26th Street and Archer Avenue in Chicago (Englewood Quad.); and along the Fox Valley southwest of South Elgin (Geneva Quad.) and east of Oswego (Aurora South Quad.).

The lower few feet of the Kankakee is more massive and contains abundant corals, scattered quartz sand grains, and small, bright green grains of glauconite. The fossil brachiopod *Platymerella manniensis* (fig. 8) is abundant in white chert nodules at or near the base in nearly all exposures.

The uppermost bed of the Kankakee Dolomite is a distinctive white, pure, massive dolomite about 2 feet thick that is an important key bed in the Silurian section. It contains the large brachiopod *Pentamerus oblongus* (fig. 8), commonly in closely packed clusters. A similar shell called *Microcardinalia pyriformis* (fig. 8) is regionally persistent in this bed and is a guide fossil to the top of the Alexandrian Series. The top of the bed has a distinctive surface that is smooth and flat in comparison with other bedding planes. However, the smooth surface has sharp pits one-fourth to one-half inch wide and equally deep, most of them filled with green clay. The pits are more or less regularly distributed, roughly 10 to 15 to a square foot. This bed is recognized throughout the area, and because it varies only a few inches in thickness, the smooth surface on top can hardly be an erosional surface. It appears more likely to be a solution surface, also called a corrosion surface, formed by a change in the sea water that favored solution rather than deposition. The pits may have been made by stems or roots of plants attached to the sea floor.

Fig. 10 - Exposures of Ordovician, Silurian, and Pennsylvanian formations

A - Carbondale Formation (Pennsylvanian) overlain by glacial till of the Wedron Formation (the smooth surface at top) along Waupecan Creek, $2\frac{1}{2}$ miles southwest of Morris (Morris Quad.). The cross-bedded Vermilionville Sandstone Member at the top of the Carbondale overlies 12 feet of Canton Shale (smooth surface). A ledge of black slaty shale lies at the base of the Canton Shale and below it is a prominent ledge of the Covel Conglomerate with associated limestone lenses.

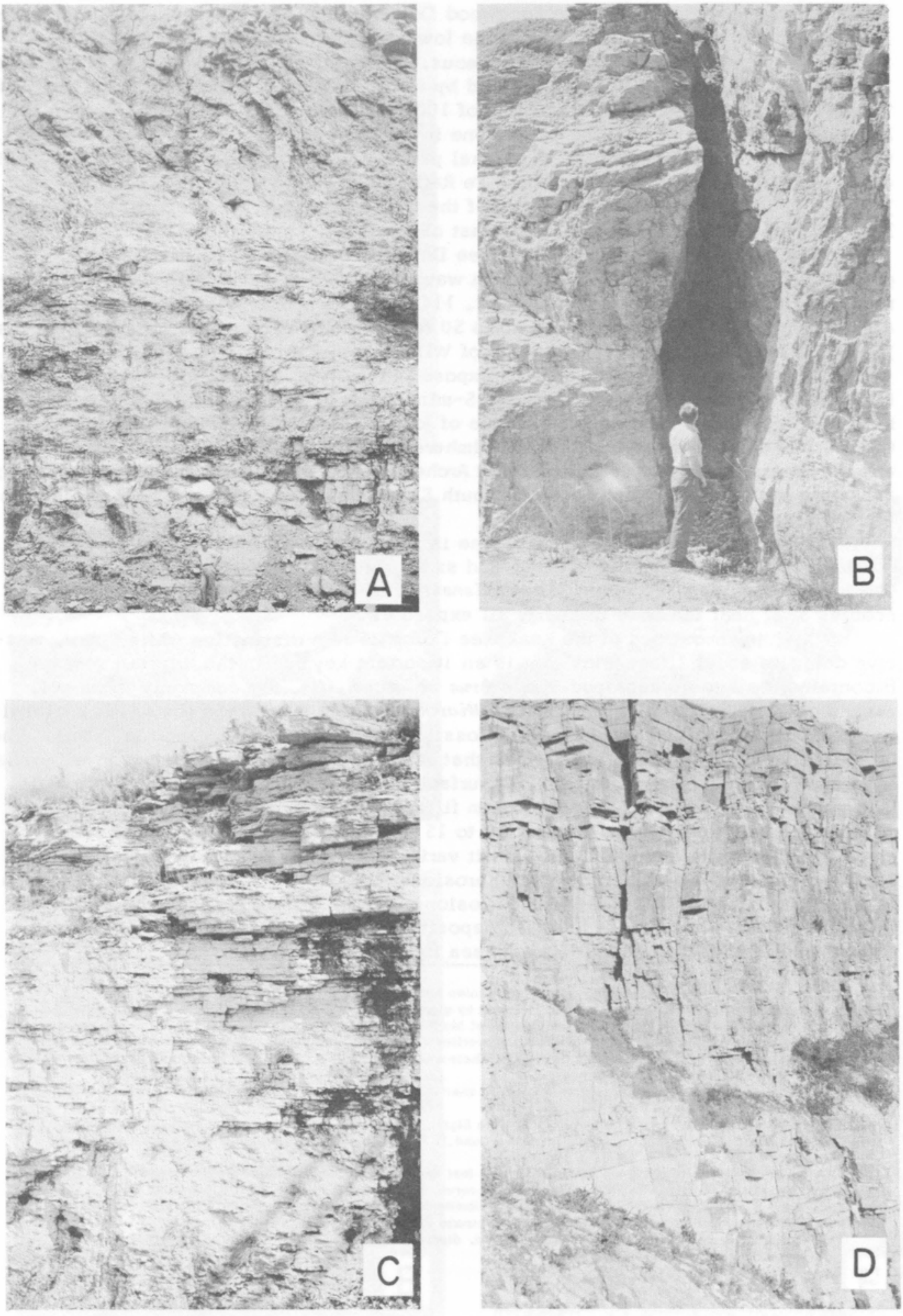
B - Limestone of the Galena Group (Ordovician) in quarry at Central, 7 miles north of Morris (Lisbon Quad.). The quarry face is about 50 feet high.

C - Fort Atkinson Limestone (Ordovician) along the Elgin, Joliet, and Eastern Railroad at Divine, 1 mile southwest of Dresden Island Lock and Dam (Minooka Quad.). The limestone is crinoidal and pink and the beds are lenticular.

D - Edgewood Dolomite (Silurian) filling channel 4 feet deep in Maquoketa Group shale (Ordovician) along the Atchison, Topeka, and Santa Fe Railroad south of curve, 5 miles southwest of Joliet (Channahon Quad.).

E - Racine Dolomite (Silurian) showing massive dolomite of reef core exposed in Material Service Corporation Stearns quarry, 26th Street and Archer Avenue, Chicago (Englewood Quad.).

F - Racine Dolomite (Silurian) showing well bedded, dipping, reef-flank beds in Material Service Corporation quarry at Thornton (Calumet City Quad.).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Niagaran Series

Joliet Dolomite - The Joliet Dolomite is 40 to 60 feet thick and has three distinctive units. The basal unit, 5 to 20 feet thick, is shaly and is characterized by interbedded red coarse-grained dolomite and greenish gray, fine-grained, argillaceous dolomite. The beds are separated by red and green shale partings. Near the middle of the basal unit a bed of green shale as much as 3 feet thick is present locally. The middle unit, 20 to 30 feet thick, consists of medium-bedded, light gray, nearly white, fine-grained, cherty dolomite that is very silty at the base but grades to only slightly silty at the top. The upper unit, 20 to 25 feet thick, is nearly white, locally mottled pink, vuggy, pure dolomite. It is thin bedded but the bedding is faint. The lower part contains a few beds of white chert (fig. 11D).

The type section of the Joliet Dolomite is in the National Stone Company (Vulcan Materials) quarry at Joliet (Joliet Quad.) (fig. 11D). The formation is well exposed in other quarries at Joliet, in the south bluffs of the Des Plaines Valley west of Joliet (Elwood Quad.), along the Du Page River at Naperville (Naperville and Normantown Quads.), along the Fox Valley at Batavia and Aurora (Aurora North Quad.), and in the same deep quarries as the Kankakee Dolomite.

Waukesha Dolomite - The Waukesha Dolomite was called the "Athens marble" when it was quarried extensively for building stone used in constructing many buildings in Chicago and throughout the region. It is a slightly silty, dense to finely vuggy, fine-grained dolomite that occurs in smooth-surfaced beds that commonly are 2 to 8 inches thick but are locally as much as 3 feet thick. It is light brownish gray and weathers brown. It is exposed at the top of the National Stone Company quarry at Joliet (fig. 11D), in the Des Plaines River bluffs from Joliet northward to Romeo and eastward to Sag Bridge (Joliet, Romeoville, and Sag Bridge Quads.), and in the deep quarries at Elmhurst and Hillside. The formation is 20 to 30 feet thick in the outcrop areas, but it is locally missing in the subsurface in the eastern part of the region.

Racine Dolomite - The Racine Dolomite is as much as 300 feet thick along the eastern edge of the region, but it thins westward because of truncation by the present bedrock surface. The lowest beds are exposed at the top of the Des Plaines Valley bluffs from Joliet to Sag Bridge. The lower and middle parts are exposed in the quarries at Hillside (Hinsdale Quad.) and Elmhurst (Elmhurst Quad.). The quarries at Hodgkins, McCook, and LaGrange (Berwyn Quad.) are in the middle part. The upper part is exposed in the Stearns quarry in Chicago (Englewood Quad.), in the Thornton quarry (Calumet City Quad.), and in small exposures at Stony Island (Lake Calumet Quad.) and Chicago Heights (Calumet City Quad.).

The Racine Dolomite is characterized by the presence of large reefs, some of which grew to heights of 100 feet or more above the surrounding sea floor. Some reefs are nearly circular, some are oval, and some are in overlapping complexes. The dolomite in the reefs is exceptionally pure, containing only traces of argillaceous material

Fig. 11 - Exposures of Silurian formations

A - Racine Dolomite (Silurian) showing a reef with dipping beds in the upper third of the quarry face overlying horizontally bedded inter-reef rock. Federal quarry of the Material Service Corporation at La Grange (Berwyn Quad.).

B - Racine Dolomite (Silurian) showing a crevice, or joint, in the dipping flank beds of a reef. The crevice contained shale with Mississippian-Devonian shark's teeth. Material Service Corporation quarry at Thornton (Calumet City Quad.).

C - Kankakee Dolomite (Silurian) showing the typical thin and wavy beds overlying the massive bed that occurs at the base of the formation. Small quarry along Atchison, Topeka, and Santa Fe Railroad, 1.5 miles southwest of Brandon Bridge (Channahon Quad.).

D - The Waukesha Dolomite (Silurian), the well bedded dolomite in the upper fifth of the 75-foot quarry face. It overlies the Joliet Dolomite (Silurian), the upper half of which (darker colored) is the relatively pure massive unit with thin beds of white chert. The lower part (lighter colored) is the well bedded, slightly silty middle Joliet unit. National Stone Company quarry on the south side of Joliet (Joliet Quad.).

and rare, isolated sand grains. With a few minor exceptions, the reef rock contains no chert. The dolomite is medium gray, mottled with light or dark gray. Because it has a low iron content, it weathers gray. Most beds are conspicuously vuggy. In a few localities the vugs are partly filled with asphaltum, a solid petroleum residue that on hot days melts and oozes from the vugs on quarry faces.

The reefs are surrounded by argillaceous and silty dolomite, and lenses of green shale are locally present. In contrast to the dolomite of the reefs, the interreef rock is fine grained, dense, commonly cherty, light brownish gray, and weathers brown. Small reefs consisting of lenses of massive, pure dolomite occur on the slopes of the major reefs and in the interreef beds.

The larger reefs have a central area, or core, of massive to irregularly bedded dolomite (fig. 10E). The marginal areas, broader than the core in some reefs, consist of dipping beds, called flank beds (fig. 10F). The flank beds entirely surround some reefs and show the successive stages of outward growth of the reef, partly by growth of reef-building organisms on the outer slope of the reef, partly by deposition of debris eroded by waves and washed down the flank. The beds dip as much as 30 degrees, but at their outer margin they flatten and grade into argillaceous interreef types of sediments. In places the argillaceous beds continue short distances up the flanks, showing intermittent encroachment of the interreef sediments. When the reefs ceased to grow, they were entirely overlapped by the argillaceous sediments.

The lowest base of a large reef is at the top of the Joliet Formation. Other reefs start at higher positions (fig. 11A). Some extend to the top of the Racine Formation and probably extended higher before being eroded along the sub-Middle Devonian unconformity.

A large reef has been progressively exposed during development of the quarry of the Material Service (General Dynamics) Corporation at Thornton (Harvey and Calumet City Quads.). The transition from the reef core through reef flank deposits and marginal reefs (fore reefs) to interreef rocks is well exposed, and the lithology, structure, and paleontology of the reef have been described in numerous reports (Bretz, 1939; Lowenstam, 1950; Lowenstam, Willman and Swann, 1956; Willman, 1962; Ingels, 1963).

DEVONIAN SYSTEM

Rocks of Devonian age are present in the Chicago area beneath Lake Michigan, only a few miles offshore, and the entire area was probably covered by several hundred feet of Devonian rocks that were deposited in the middle and late Devonian seas. Devonian limestone overlain by black shale occurs in Indiana only a short distance east of the Illinois-Indiana state line. Black shale, probably the Grassy Creek Shale of Upper Devonian age, has been found in pockets on top of the Silurian dolomite at Elmhurst. Shale in joints in the Silurian Dolomite in the Thornton reef contains sharks' teeth that are Devonian or Mississippian in age (Bretz, 1939) (fig. 11B). The shale assigned to the Mississippian Hannibal Formation in the fault blocks of the Des Plaines Disturbance (fig. 13) may be equivalent to the Ellsworth Formation of Michigan and Northern Indiana, in which case only the uppermost part is Mississippian and the lower part is late Devonian in age (J. A. Lineback, personal communication).

MISSISSIPPIAN SYSTEM

Rocks of Mississippian age at one time probably covered the entire Chicago area, but they are now present only in the fault blocks of the Des Plaines Disturbance and are not exposed (fig. 13). In the fault blocks as much as 500 feet of shale and siltstone is assigned to the Hannibal Shale of early Mississippian (Kinderhookian) age, although, as previously noted, it may include a large proportion of late Devonian shale. The shale is overlain by 200 feet of cherty limestone, the Burlington-Keokuk Limestone of middle Mississippian (Valmeyeran) age. The Devonian-Mississippian rocks overlie Silurian dolomite and are overlain by Pennsylvanian shale. As Pennsylvanian strata rest directly on pre-Devonian rocks in the southern part of the area and for 50 miles farther southwest, the preservation of the Devonian and Mississippian rocks on the high part of the Kankakee Arch is anomalous, and it suggests that there may have been faulting in the Des Plaines structure in late Mississippian or early Pennsylvanian time.

PENNSYLVANIAN SYSTEM

The rocks of the Pennsylvanian System were originally called "Coal Measures" because they contain the important coal seams. Pennsylvanian rocks underlie the southwestern corner of the Chicago area (fig. 9) and are well exposed along the Mazon River (Coal City Quad.), along Waupecan Creek (Morris Quad.), in the coal strip mines near Coal City, and along the lower few miles of the Kankakee River (Coal City and Wilmington Quads.) (pl. 1). Pennsylvanian rocks formerly covered the entire Chicago area. They have been eroded from the area north and east of Joliet, except in the Des Plaines Disturbance where they occur in a fault block (fig. 13). They are the youngest bedrock formations exposed in the Chicago area and belong to the Desmoinesian Series. They were deposited during the middle part of the Pennsylvanian Period. However, in a few localities the basal Pennsylvanian strata may belong to the older Atokan Series.

The Pennsylvanian rocks are largely shale and sandstone, but they differ notably from the older Paleozoic formations, which are largely thick units dominated by a single rock type — dolomite, sandstone, or shale. The Pennsylvanian succession consists of much thinner units and many more types of rock.

During Pennsylvanian time the sea repeatedly advanced over the area from the south. Consequently, the deposits are alternately marine and nonmarine. The deposits of a marine-nonmarine cycle are called a cyclothem and are generally arranged in the same order in successive cyclothems. The base of a typical cyclothem is fine-grained, silty, micaceous sandstone or sandy siltstone, overlain successively by sandy shale, nodular limestone, claystone (also called underclay), coal, and gray shale. These are the nonmarine units of the cyclothem. In some areas the gray shale at the top is a marine or brackish-water deposit. Above the gray shale, or where it is absent, resting directly on the coal, is a black, slate-like shale that contains marine fossils and, in places, large oval concretions of limestone. The black shale is overlain by fossiliferous, gray, slightly argillaceous limestone or by limestone and calcareous shale interbedded. Above the limestone is a gray shale, the lower part of which generally contains marine fossils. These are the marine units in the cyclothem Above the gray shale is the sandstone that forms the basal unit of the next higher cyclothem. In places the sandstone fills channels that cut into the shale and locally extend down to the coal or below.

Successive cyclothems are never identical, because some units are missing and units that correspond differ in thickness and in minor lithologic characteristics. The cyclothems vary from a few to 75 feet thick, depending largely on the thickness of the sandstones and the degree to which they truncate the underlying cyclothems.

Parts of three cyclothems are exposed along the Mazon River near the mouth of Johnny Run (Coal City Quad.) and along Waupecan Creek for a mile south of the Boy Scout Camp (Morris Quad.) (fig. 10A). In both of these areas the section exposed begins with the Vermilionville Sandstone Member, which is the basal unit of the Brereton Cyclothem, and extends downward through the St. David and Summum Cyclothems. The St. David Cyclothem lacks a coal and a basal sandstone in this area. The position of the sandstone is occupied by a distinctive but thin bed of limestone conglomerate, the Covel Conglomerate Member. The conglomerate is only a foot or two above the Hanover Limestone Member in the Summum Cyclothem. Farther down the two valleys the Pleasantview Sandstone Member at the base of the Summum Cyclothem is exposed, and below it the Francis Creek Shale Member also is exposed. The Francis Creek Shale, the underlying Colchester (No. 2) Coal, and the underclay of the coal are included in the Liverpool Cyclothem and are exposed in the strip mines. Immediately south of the Chicago area, and perhaps locally within the area, the Lowell Cyclothem is present above the Francis Creek Shale and below the Pleasantview Sandstone, and the Liverpool Cyclothem is replaced by the Lowell (above) and Tonica Cyclothems. Below the Liverpool Cyclothem the Pennsylvanian strata are less uniform and include interbedded clays, thick local sandstones, and thin beds of shale and limestone. They probably represent several cyclothems.

As the distinctive individual units in the cyclothems are not thick enough to be practical formations, the Pennsylvanian rocks are divided into larger units that show major changes in the dominant rock types. In the Chicago area the strata belong to two formations, the Spoon Formation below, in which the coals are generally thin or local, and the Carbondale Formation above, which contains the principal commercial coals and extends from the Colchester (No. 2) Coal Member at its base to the Danville (No. 7) Coal Member at its top. However, the upper part of the Carbondale Formation is eroded in this area. The Pennsylvanian strata preserved in the Des Plaines Disturbance consist of 30 feet of gray and black shale containing a bed of coal. They are included in the Spoon Formation, although their precise position in the Spoon is not known and they may include some beds of the Abbott Formation. The Spoon and Carbondale Formations make up the Kewanee Group.

The Pennsylvanian strata in the Chicago area were described by Cady (1915); Culver (1922); Willman and Payne (1942); W. H. Smith (1968); Smith et al. (1970); and Peppers (1970).

Spoon Formation - All the Pennsylvanian strata in the Chicago area that underlie the Colchester (No. 2) Coal Member are assigned to the Spoon Formation. The basal Pennsylvanian rocks vary from place to place, partly because they overlap the uneven surface of the sub-Pennsylvanian unconformity, and consequently the specific identity of isolated exposures is not easily established. Some of the basal sandstone, for example that along the Kankakee River at the county line bridge (Wilmington Quad.), could be part of the Abbott Formation that underlies the Spoon farther south. A sandstone containing quartz pebbles, which was exposed half a mile south of Channahon (Channahon Quad.) before it was covered by the lake above the Dresden Island dam, resembled conglomeratic sandstone in the still lower Caseyville Formation, which is widely developed in southern Illinois. In the same outcrop the sandstone was overlain by a fossiliferous blue-gray limestone that is like the Seville Limestone Member in the Spoon Formation in western Illinois.

The Spoon Formation is exposed in the Goose Lake clay pit 4 miles north of Coal City (Coal City Quad.), along the lower 2 miles of the Kankakee River (Wilmington and Coal City Quads.), and along Aux Sable Creek near the Illinois and Michigan Canal (Minooka Quad.). Except at Goose Lake, where the beds are largely clay but include thin coal, limestone, and shale, the Spoon Formation is mostly shale and sandstone. The formation has a maximum thickness of 75 feet where it is overlain by the Carbondale Formation.

Carbondale Formation - The Carbondale Formation consists of all the Pennsylvanian strata in the Chicago area above the base of the Colchester (No. 2) Coal Member. Because of its southwesterly dip, the formation thickens from the outcrop of the coal to about 125 feet in the extreme southwestern part of the area. The No. 2 Coal is generally about 3 feet thick, but it varies from 2 to 4 feet. It is the only commercial coal in the area. It is best exposed in the strip mines south of Braidwood (Wilmington Quad.). In the outcrops, the Summum (No. 4) Coal Member is only 1 to

2 inches thick and the Springfield (No. 5) Coal Member is absent, but both are locally present and thicker in the subsurface just south of the area. The Carbondale Formation includes two sandstones 10 to 20 feet thick. The Pleasantview Sandstone Member, in the interval between the No. 2 and No. 4 Coals, is exposed along the Mazon River 2 miles northwest of Carbon Hill (Coal City Quad.) and at Pine Bluff Bridge, 2 miles southeast of Morris (Morris Quad.). The Vermilionville Sandstone Member, above the No. 5 Coal, is the youngest Pennsylvanian bed in the area, and it is well exposed along Waupecan Creek 3½ miles south of Morris (Morris Quad.) (fig. 10A).

The gray shale that overlies No. 2 Coal — the Francis Creek Shale Member — is famous world-wide for the "Mazon Creek fossils," which occur in concretions in the lower few feet of the shale (fig. 8). These oval-shaped concretions are commonly half an inch to 2 inches thick and from 2 to 6 inches long. A few are considerably larger. They are largely siderite (iron carbonate) and have a thick outer rim of limonite produced by weathering. Only 5 to 10 percent of the concretions contain well preserved fossils, and these can be easily split parallel to the bedding. Although plants of great variety are by far the most common fossils, many types of animals — amphibians, insects, crabs, worms, lung fish, and many others — have also been found (for references see Willman et al., 1968, and Smith et al., 1970). The lower part of the shale, which contains the fossiliferous concretions, is exposed along the Mazon River at two localities, 1½ and 2 miles southeast of Pine Bluff Bridge (Coal City Quad.), and also in the coal strip mines. Concretions are generally common higher in the shale but are rarely fossiliferous. Even in the mined areas fossiliferous concretions are only locally abundant. They are exposed when rain washes the waste piles of the strip mines and the conical waste piles from the underground mines.

BEDROCK STRUCTURE

The bedrock formations were deposited on slopes that had only slight inclinations, and as a result the bedding planes were essentially flat. Some beds of the sandstones and coarse-grained limestones, however, are steeply inclined, or cross-bedded. In much of the Chicago area the dips of the beds are too slight to be observable in individual outcrops. However, comparison of the elevations of the same bed in exposures only a few hundred feet apart generally shows even slight dips.

As the area has been subjected to regional tectonic movements (described in the section on stratigraphic relations), none of the formations shows its original depositional slope — in fact, many now dip in a different direction. Furthermore, the Paleozoic formations are not all parallel. During the Ordovician Period, before the St. Peter Sandstone was deposited, the formations were tilted and eroded. Tectonic movement also occurred before Middle Devonian deposition and again before Pennsylvanian deposition (fig. 6). As a result, the formations meet at low angles at all of these unconformities. This effect is distinctly noticeable at points a few miles apart, and the divergence of the formations can be determined by comparing structure maps of different units (Suter et al., 1959; Buschbach, 1964).

Although the Chicago area is on the crest of the broad, gentle-sloped Kankakee Arch (fig. 1), the strata have a general eastward dip that results from the eastward plunge of the arch (fig. 12). The broad regional movements were accompanied by local warping that produced gentle anticlinal and synclinal structures that have east-west axes (Suter et al., 1959, fig. 16). The beds were broken in some places, and faults that have displacements of a few feet to as much as 20 feet are not uncommon. Major faults occur in the Sandwich Fault Zone in the southwestern part of the region and in the Des Plaines Disturbance northwest of Chicago.

The major structural features are depicted on a structure map (fig. 12) that shows the variations in elevation of the top of the Glenwood Formation, or of the St. Peter Sandstone where the Glenwood is absent. This horizon is also the base of

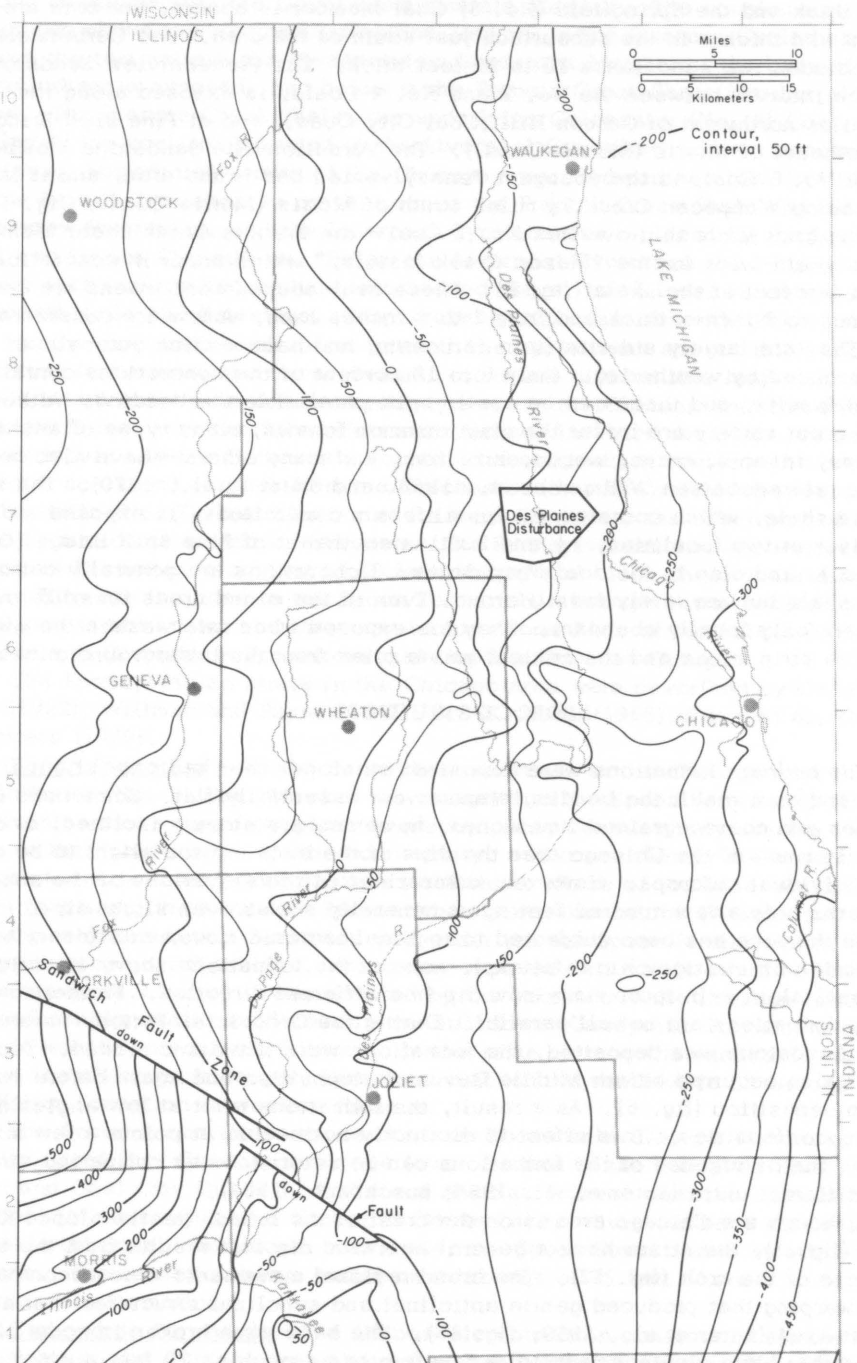


Fig. 12 - Geologic structure of the Chicago area. Contours on top of the Glenwood and St. Peter Sandstones (after Buschbach, 1964).

the Platteville Group (fig. 5). The top of the Glenwood Formation is more than 500 feet above sea level in the southwestern part of the area, but it is 500 feet below sea level in the southeastern corner, a decline of 1,000 feet in 50 miles and an average of 20 feet per mile. Throughout most of the Chicago area the dip is 10 to 15 feet per mile.

Sandwich Fault Zone

The Sandwich Fault Zone (fig. 12) extends southeastward from the vicinity of Oregon for a distance of about 80 miles, into the southern part of the Chicago area (Willman and Templeton, 1951; Suter et al., 1959; Buschbach, 1964; Willman and others, 1967). Where exposed near its northwestern end, the fault is about 100 feet wide and the rocks are intensely sheared. The bordering rocks are broken by many faults that have small displacements. The fault zone appears to be nearly vertical and, relative to each other, the rocks on the north side were moved down and those on the south side were moved up. The drag, or upward bend, of the rocks on the downthrown side of the fault is exposed along the Fox River at Millhurst, 2 miles west of the boundary of the Chicago area. The maximum displacement of the beds is 900 feet 20 to 30 miles west of the Chicago area, but near the ends of the fault, the displacement diminishes abruptly. At the western edge of the Chicago area, the displacement is about 250 feet, which decreases eastward to zero in about 18 miles.

A few miles farther east on nearly the same alignment, a fault that has a maximum displacement of about 100 feet has the downthrown side on the south. If it is directly connected with the Sandwich Fault Zone, only a scissors-like movement on the fault plane can explain the difference in direction of displacement. The eastern fault is generally interpreted as a parallel fault slightly offset to the south. The place where it crosses the Des Plaines Valley is shown on plate 1. The fault plane is not exposed, but the change from Ordovician rocks north of the fault to Silurian at the same level on the south can be observed (Channahon Quad.).

The youngest rocks broken by the Sandwich Fault Zone are Silurian in age, and the faulting, therefore, is younger than Silurian. Although Pennsylvanian rocks have been eroded from the Sandwich Fault Zone, major folding and faulting west and south of the Chicago area involved Pennsylvanian rocks. The fault zone therefore may be post-Pennsylvanian in age, and it most likely is related to the major disturbance at the end of the Paleozoic Era.

Des Plaines Disturbance

The Des Plaines Disturbance (fig. 13) is an unusual structural feature, the origin of which has aroused much discussion. At Des Plaines in northwestern Cook County, the rocks in an area about 5½ miles in diameter are intensely faulted. Displacements as much as 600 feet bring rocks as old as the St. Peter Sandstone and Oneota Dolomite to the bedrock surface in the central part of the structure and carry downward Mississippian and Pennsylvanian strata that are not present elsewhere in the region nearer than 50 miles. The disturbance is surrounded by nearly horizontal Silurian dolomite in which drilling has revealed no faults.

The description and interpretation of the structure by Emrich and Bergstrom (1962) are based on the records of 295 wells and the study of samples from 102 of the wells. The wells provide all the information that is available. The bedrock is buried beneath 75 to 200 feet of glacial drift, and there is no indication of the structure on the present surface. The structure is probably even more complex than is indicated by the drill data.

The intensity of the deformation in a local, roughly circular area relates the structure to others widely scattered through the Midwest that are called cryptoex-

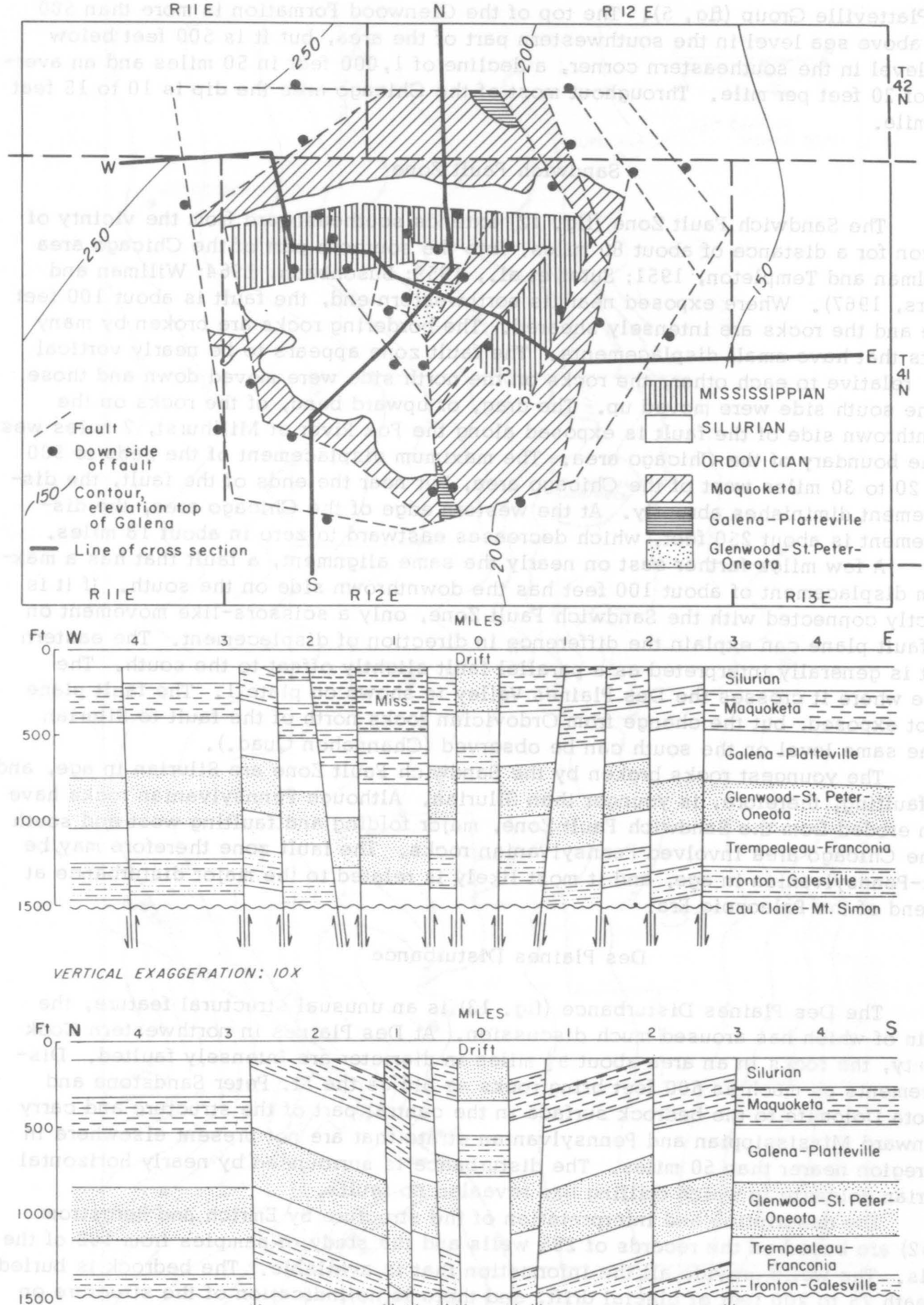


Fig. 13 - Geologic map and cross sections of the Des Plaines Disturbance (after Emrich and Bergstrom, 1962).

plosion structures. Earlier these structures were thought to be formed by the sudden release of gases from below and were called cryptovolcanic structures. More recently shatter cones, minerals formed only at very high pressures, and explosion breccias have been found in many of the other structures. This evidence suggests that these structures were formed by the impact of meteorites.

Because the Des Plaines structure is not exposed, these features are not observable, and they have not been found in the few available cores. Furthermore, the faults appear to be essentially vertical. In most wells a normal sequence is found below whatever the uppermost rock happens to be, which suggests that the beds in the fault blocks are nearly horizontal (fig. 13). In other structures more definitely formed by meteorite impact, the beds in many of the fault blocks are nearly vertical. Although the Des Plaines structure, like the others, has a central uplift, the intensity of deformation is much less. If the Des Plaines Disturbance is the result of a meteorite impact, it may be only the lower part of the deformed zone, where the deformation was diminishing. More than 1,000 feet of younger Paleozoic rocks, now absent, could have been present over the Silurian strata in this area near the end of the Paleozoic Era.

As Pennsylvanian rocks are present in the structure, it is late Pennsylvanian or younger in origin. However, the presence of 700 feet of late Devonian and Mississippian rocks in some of the fault blocks and their absence beneath the Pennsylvanian rocks in the southern part of the area and for 50 miles farther south suggests, although it does not prove, that some of the faulting is pre-Pennsylvanian. If the faulting occurred at more than one time, the structure was not formed by meteorite impact. Therefore, origin by meteorite impact, although favored, remains uncertain.

BEDROCK SURFACE

The surface of the bedrock (fig. 14) is an undulating plain in which steep-sloped valleys as much as 100 to 150 feet deep are entrenched (Horberg, 1950; Piskin and Bergstrom, 1967). The slopes on the bedrock surface are rarely parallel to the slopes of the present topography (fig. 20), and it is apparent that the modern rivers and streams have had little to do with formation of the bedrock surface. The glacial deposits almost completely filled the valleys in the bedrock surface, and the glaciers left their own distinctive topography. This resulted in the establishment of new drainage lines generally discordant with the earlier valleys. Except for a few miles, and there more or less accidentally, the present valleys are not reexcavated bedrock valleys.

The surface of the bedrock is the sub-Pleistocene unconformity. It truncates the Paleozoic formations (fig. 9), and the influence of differences in hardness, or resistance to erosion, is evident only locally. The surface passes from the Silurian and Ordovician dolomites westward to the shale of the Maquoketa Group and southwestward to the Pennsylvanian sandstones and shales, but the boundaries are not apparent on the bedrock surface map (fig. 14). The bedrock surface drainage divide (fig. 21), which would separate the Great Lakes and Mississippi River drainage if it were the present surface, is on the Silurian dolomite in the southern part of the area, but it turns westward onto the Maquoketa Shale in the central western part.

Although the beveled surface of the bedrock formations may be attributed partly to inheritance from older erosional surfaces, the surface is fresh and unweathered under the glacial drift. The preglacial surface probably was shaped and generally lowered, perhaps 100 feet or more, by glacial erosion. The sharp valleys in the bedrock surface are the lower parts of deeper valleys that were cut during the Sangamonian Stage of deglaciation, or possibly earlier, were then truncated by the Wisconsinan glaciers, and were finally filled with Wisconsinan drift.

A deep buried valley extending northeastward from Joliet (fig. 14) is called Hadley Valley (Horberg and Emery, 1943; Bretz, 1955; Suter et al., 1959). At the divide where it connects with a northeastward-sloping valley, the Hadley Valley is still entrenched about 100 feet into the bedrock surface. It is nearly 100 feet lower than the bedrock divide along the channel of the Des Plaines Valley, which was entrenched in the bedrock surface by the Outlet River of Lake Chicago. Hadley Valley may have been formed by the overflow of a glacial lake, an ancestral Lake Chicago, which formed in the Lake Michigan Basin when the Illinoian glacier retreated or the Wisconsinan glacier first advanced. It was overridden by the Wisconsinan glaciers and partially filled with glacial deposits. Short segments were reexcavated by Spring Creek (Mokena Quad.).

GLACIAL STRATIGRAPHY

QUATERNARY SYSTEM

The Quaternary System consists of all the rocks younger than the Tertiary, including those accumulating at present. As the system contains only one series, the Pleistocene, the terms Quaternary and Pleistocene apply to the same rocks (fig. 15).

PLEISTOCENE SERIES

The Pleistocene Series includes all the unconsolidated rock formations in the Chicago area that overlie the Paleozoic bedrock. These deposits are related predominantly to the glaciers that repeatedly covered the area, but they also include deposits made since the glaciers melted — by rivers and streams, by slopewash and slumping, by sedimentation in lakes and ponds, and by the work of man.

The advancing glaciers eroded the bedrock formations, as is evident from the scratches (striations) on the bedrock surface, and the lower parts of the glaciers became loaded with rock debris of all sizes from clay and silt to cobbles and boulders. Shearing movements in the ice produced a grinding action that pulverized many rocks to small fragments and thoroughly mixed materials from many different rock formations.

When the ice melted it deposited a material called till (fig. 17A) that is an unsorted mixture of rock fragments of all sizes. The kind and size of the rocks in the till are both related to the kinds of rocks overridden by the glacier. Because the glaciers took different courses across different rock formations, they deposited tills with different compositions. Mineral and grain-size analyses, therefore, are useful in differentiating some of the tills.

As the glaciers melted, water flowing in channels on, in, and below the ice picked up rock debris and began the process of sorting it by size. When reduction in volume or velocity of the water resulted in quick deposition of the coarser materials in channels in the glacier or along its margins, much of the clay and silt remained in suspension and was carried away from the ice. The sand and gravel thus deposited is poorly sorted and has irregular and distorted bedding (fig. 17C). These ice-contact sand and gravel deposits occur in conical hills (kames), in elongate ridges (eskers), and in lenses within the till sheets.

Sand and gravel transported away from the ice by meltwater streams before it was deposited is better sorted and is called outwash. Sheet-like deposits of outwash along the front of the glaciers are called outwash plains. Outwash deposits in valleys are called valley trains. When the outwash was carried by the streams into lakes, the materials were further sorted. Near the shore, sand and gravel were deposited in beaches, bars, spits, and deltas, while clay, silt, and fine sand were deposited in the deeper water.

Water flowing from glaciers transports large quantities of silt, clay, and sand. These fine-grained materials give the meltwaters of modern glaciers a cloudy, or

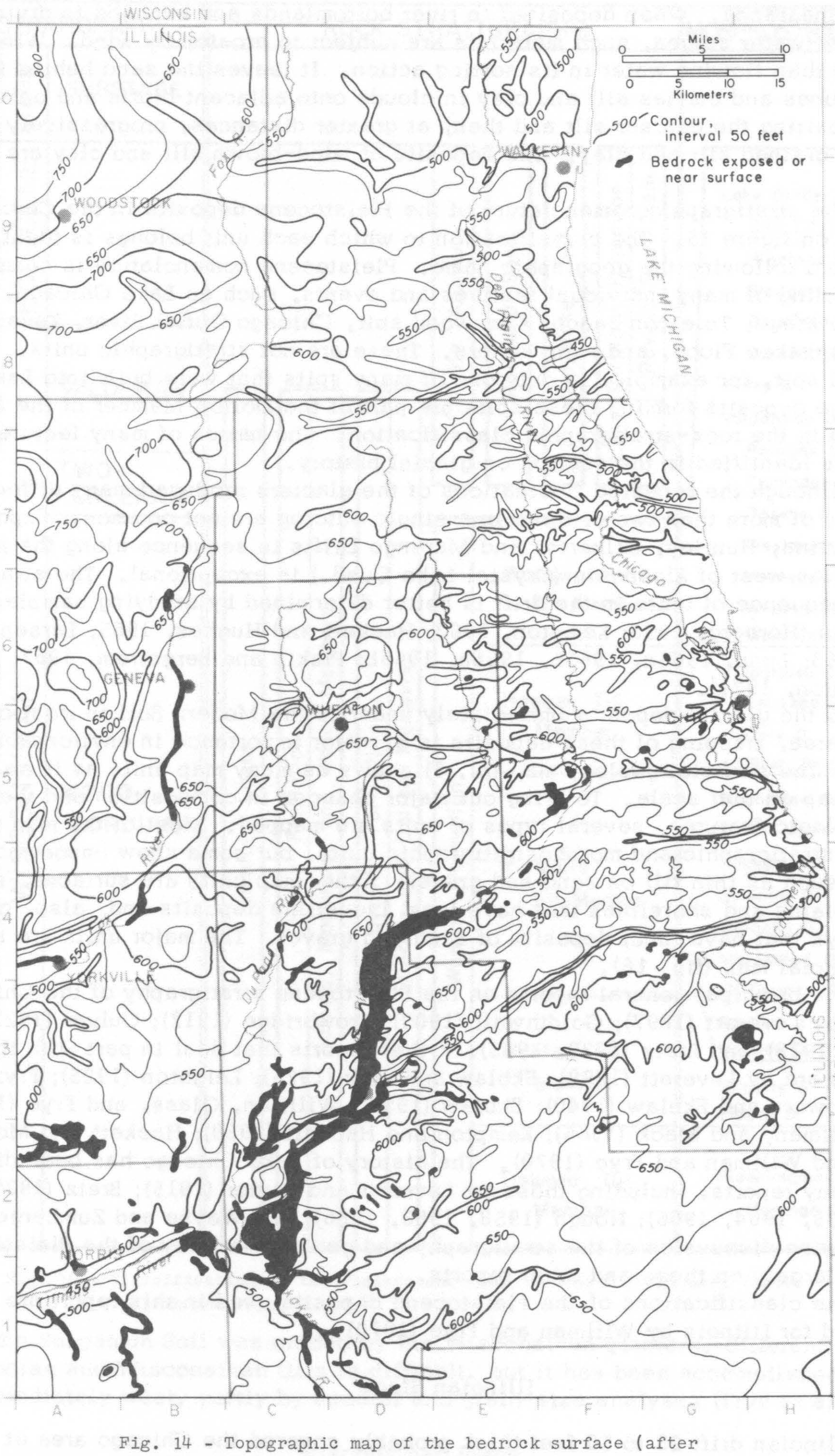


Fig. 14 - Topographic map of the bedrock surface (after Suter et al., 1959).

milky, appearance. When deposited in river bottomlands and exposed to drying winds during low-water stages, such materials are subject to erosion by wind. Wind is more selective than flowing water in its sorting action. It leaves the sand behind in slow-moving dunes and carries silt and clay in clouds onto adjacent bluffs and uplands, first depositing the coarser silt and then, at greater distances, progressively thinner and finer grained silt and clay. The deposits of wind-blown silt and clay are called loess.

The stratigraphic nomenclature of the Pleistocene deposits in the Chicago area is shown on figure 15. The classification to which each unit belongs is identified by the word following the geographic name. Pleistocene nomenclature is complicated by the naming of many individual features and events, such as Lake Chicago, Calumet lake stage, Toleston beach, Glenwood spit, Chicago Outlet River, Kaneville Esker, Kankakee Flood, and many others. These are not stratigraphic units. The Glenwood spit, for example, is only one of many spits that were built into Lake Chicago. The deposits forming these spits are part of the Dolton Member of the Equality Formation in the rock-stratigraphic classification. The names of many features and events are identified in the section on glacial history.

Although the repeated fluctuations of the glaciers produced many different units, exposures of more than two or three in a single outcrop are not common. Exposures of the Barlina, Huntley, Gilberts, and Marengo Drifts in sequence along the Huntley road 2 miles west of Algonquin (Crystal Lake Quad.) is exceptional. The stratigraphic sequence of units in the drift is better determined by studying samples from drill holes (Horberg, 1953; Kempton, 1963; Hackett and Hughes, 1965; Larsen and Lund, 1965; Lund, 1965a, 1965b, 1966a, 1966b; Piskin and Bergstrom, 1967; Landon and Kempton, 1971).

As the glacial deposits immediately underlie the Modern Soil in most of the Chicago area, mapping of these deposits is of major importance in environmental geology. The surficial geology map (pl. 1) shows as many map units as it was practical to map on that scale. To bring out major changes in composition and the principal geologic features, several types of units are mapped. Most of the map units are rock-stratigraphic and morphostratigraphic units, but some show important relations, such as thin till on sand and gravel. Other map units are surfaces, such as lake plains and shorelines that have local lacustrine deposits and, also, glacial sluiceways that have local deposits of sand and gravel. The major units are shown on the glacial map (fig. 16).

The principal general reports on the Pleistocene stratigraphy of the Chicago area are by Leverett (1897); Goldthwait (1909); Trowbridge (1912); Culver (1922); Fisher (1925, 1928); and Bretz (1939, 1955). Other reports that deal in part with the Chicago area are by Leverett (1899); Ekblaw and Athy (1925); Leighton (1925); Fryxell (1927); Powers and Ekblaw (1940); Ekblaw (1959); Willman, Glass, and Frye (1963); Frye, Willman, and Black (1965); Kempton and Hackett (1968); Hackett and McComas (1969); and Willman and Frye (1970). The history of Lake Chicago has been discussed in many reports, including those by Leverett and Taylor (1915); Bretz (1939, 1951, 1955, 1964, 1966); Hough (1958, 1963, 1966); and Wayne and Zumberge (1965). The following discussion of the stratigraphy and geologic history of the Pleistocene is based largely on these and other reports.

The classifications of the Pleistocene deposits used in this report are those introduced for Illinois by Willman and Frye (1970).

Illinoian Stage

Illinoian drift 25 to 50 feet thick probably covered the Chicago area at the beginning of Wisconsinan glaciation, but it was eroded and no Illinoian drift has been definitely identified in the area. Patches of Illinoian drift may remain in protected localities, particularly in the western parts of McHenry and Kane Counties.

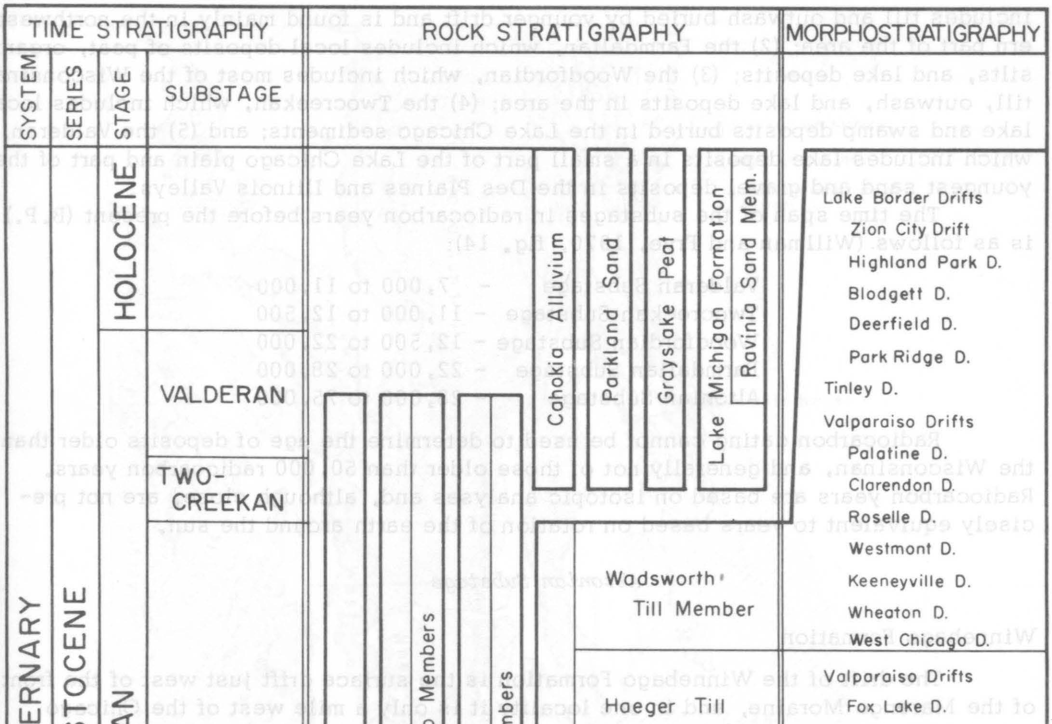


Fig. 15 - Classification of the Pleistocene rocks of the Chicago area (after Willman and Frye, 1970).

Where the Sangamon Soil was eroded by the Wisconsinan glaciers, differentiation of the Illinoian and Wisconsinan tills is difficult, but it has been accomplished in the area immediately west, partly by mineral and grain-size analyses (Frye et al., 1969).

Wisconsinan Stage

The glacial deposits in the Chicago area are almost entirely Wisconsinan in age. The Wisconsinan Stage is subdivided into five substages: (1) the Altonian, which includes till and outwash buried by younger drift and is found mainly in the northwestern part of the area; (2) the Farmdalian, which includes local deposits of peat, organic silts, and lake deposits; (3) the Woodfordian, which includes most of the Wisconsinan till, outwash, and lake deposits in the area; (4) the Twocreekan, which includes local lake and swamp deposits buried in the Lake Chicago sediments; and (5) the Valderan, which includes lake deposits in a small part of the Lake Chicago plain and part of the youngest sand and gravel deposits in the Des Plaines and Illinois Valleys.

The time span of the substages in radiocarbon years before the present (B.P.) is as follows (Willman and Frye, 1970, fig. 14):

Valderan Substage	-	7,000 to 11,000
Twocreekan Substage	-	11,000 to 12,500
Woodfordian Substage	-	12,500 to 22,000
Farmdalian Substage	-	22,000 to 28,000
Altonian Substage	-	28,000 to 75,000

Radiocarbon dating cannot be used to determine the age of deposits older than the Wisconsinan, and generally not of those older than 50,000 radiocarbon years. Radiocarbon years are based on isotopic analyses and, although close, are not precisely equivalent to years based on rotation of the earth around the sun.

Altonian Substage

Winnebago Formation

The drift of the Winnebago Formation is the surface drift just west of the front of the Marengo Moraine, and in one locality it is only a mile west of the Chicago area (pl. 1) (Frye et al., 1969). In the northwestern part of the area, the Winnebago Formation is widely present below the Marengo and younger drifts. It is exposed in a local area too small to show on plate 1 along Big Rock Creek $3\frac{1}{2}$ miles northeast of Plano on the Kane-Kendall County line (Yorkville Quad.), where two pinkish gray, silty, sandy tills are separated by a bed of silt, called the Plano Silt Member (Kempton and Hackett, 1968). The silt has been found in several borings, and peat from it has been dated at 32,600 to 41,000 radiocarbon years B. P.

In the lower parts of the bluffs, along the Des Plaines Valley from Summit to Romeo (3 miles west of Lemont) and along the Sag Channel from Worth to Sag Bridge, many exposures of yellow, silty till are associated with lenticular bodies of poorly sorted gravel and sand and cross-bedded sand and silt. These deposits are informally called the Lemont drift (Bretz, 1955; Horberg and Potter, 1955; Willman and Frye, 1970). They may be part of the Winnebago Formation. Their age is uncertain and they have been variously correlated with Illinoian, Altonian, and Woodfordian deposits. They appear to have been eroded and weathered before they were covered by Valparaiso Drift.

Farmdalian Substage

Robein Silt

Peat and organic silt deposits overlying the Winnebago Formation and underlying the Wedron Formation are assigned to the Robein Silt Formation. They were previously called Farmdale Silt. They have been encountered in borings along the Northwest Toll Road and elsewhere in the northwestern part of the area (Kempton, 1963; Kempton and Hackett, 1968). Dates of 23,000 to 26,000 radiocarbon years B.P. were obtained from the peat.

A waterlaid silt overlain by pink till of the Tiskilwa Member is exposed by a roadcut through the Cryder Lake beach escarpment 1 mile north of Morris (Morris

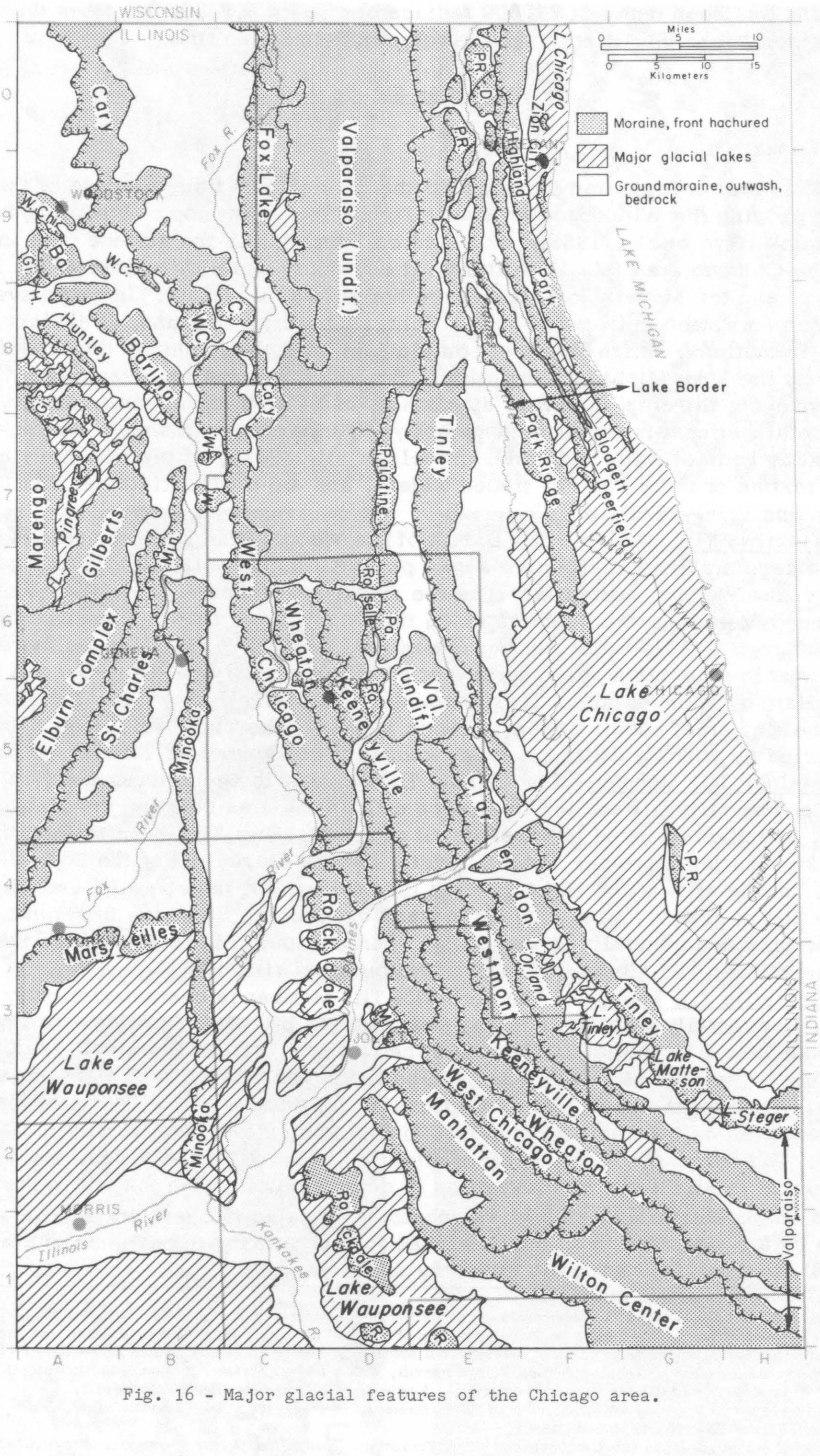


Fig. 16 - Major glacial features of the Chicago area.

Quad.) and has been dated at 24,000 radiocarbon years B.P. It indicates that a lake was present in the Illinois Valley region in Farmdalian time.

Woodfordian Substage

Wedron Formation

The Wedron Formation includes all the glacial drift from the base of the oldest till overlying the Winnebago or Robein Formations to the top of the youngest till in the region (Frye et al., 1968). The Wedron Formation is the surface drift in a large part of the Chicago area (pl. 1), although it commonly has a thin cover of the Richland Loess and the Modern Soil, which are not shown on plate 1. In extensive areas the Wedron Formation is overlain by the Henry, Equality, Parkland, Grayslake, or Cahokia Formations, which do appear on plate 1. In Lake Michigan the Wedron is overlain by the Lake Michigan Formation. The Wedron Formation averages 100 feet thick throughout the area, and it is as much as 300 feet thick in some buried valleys and in the higher moraines. It is dominantly till that occurs in sheet-like deposits separated by beds of waterlaid sand, gravel, or silt. Many of the tills have a distinctive texture or color, can be traced widely, and are differentiated as members (Willman and Frye, 1970).

Tiskilwa Till Member - The oldest of the Woodfordian till members identified in the Chicago area is a distinctive sandy pink till that is called the Tiskilwa Till Member of the Wedron Formation. It is the surface drift in the Chicago area only in the Marengo Moraine, which occurs along the west side of the area west of Elgin (Pinegree Grove Quad.). The member is exposed in many roadcuts in the Marengo Moraine and in roadcuts a mile northwest of Algonquin (Crystal Lake Quad.), where it is overlain by younger drift. It is encountered in wells throughout the northwestern part of the map area. South of the Marengo Moraine, the Tiskilwa Till Member is generally buried by younger drift, but it is exposed in roadcuts near Morris and Joliet.

Malden Till Member - The Malden Till Member is characterized by yellow-gray or pinkish gray silty till and is the surface drift in the area between the Marengo Moraine, which consists of pink sandy till of the Tiskilwa Till Member, and the Huntley and St. Charles Moraines, which consist of gray clayey till of the Yorkville Till Member. In the area of the Gilberts Drift the Malden Till incorporated enough of the Tiskilwa Till to give it a pinkish cast in many exposures. It varies from pinkish gray to yellow-gray and generally is very silty. Farther south in the area of the Elburn Drift, the Malden Till Member is largely yellow-gray silty till.

Yorkville Till Member - The Yorkville Till Member is characteristically gray clayey till, generally with few cobbles and boulders but with abundant small pebbles. It is the surface drift in the area between the Gilberts Drift or the Elburn Drift and the front of the Valparaiso Morainic System, and it includes the tills of eight moraines (fig. 16). To show the overlapping relations of the moraines, the Yorkville Member is differentiated on the geologic map (pl. 1) into two units at the front of the Minooka Moraine. The till in the older moraines (Huntley, Barlina, St. Charles, Marseilles, and Minooka) is slightly more clayey and is darker in color than the till in the younger moraines (Rockdale, Wilton Center, Manhattan). It also is characterized on weathered surfaces by a concentration of small pebbles that give it the appearance of gravel (fig. 17B), but this is readily disproved by slight digging.

Fig. 17 - Exposures of Pleistocene deposits

A - Glacial till showing the characteristic lack of sorting in a mixture of pebbles, sand, silt, and clay. Haeger Till Member of Wedron Formation, exposed at the top of a gravel pit 1 mile south of Spring Grove (Fox Lake Quad.).

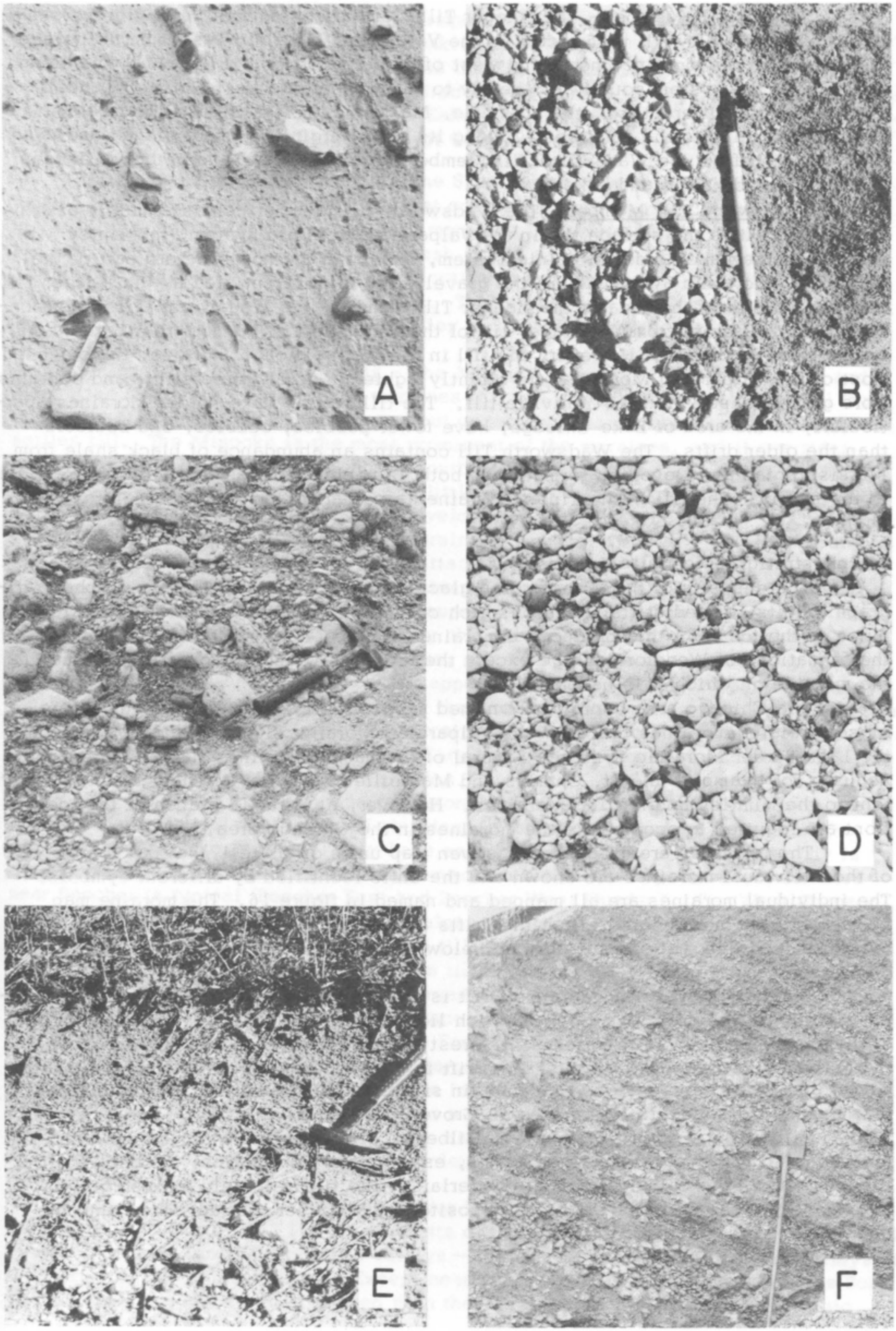
B - Comparison of weathered surface of Yorkville Till Member of Wedron Formation, which characteristically has a concentration of small angular pebbles (left of pencil), with a freshly scraped surface of the till (right). Road cut at intersection of Illinois Highways 47 and 71, 1 mile south of Yorkville (Platteville Quad.).

C - Poorly sorted gravel in Wasco Member of Henry Formation in gravel pit in the Kaneville Esker 3 miles northwest of Sugar Grove (Sugar Grove Quad.).

D - Well sorted gravel in Batavia Member of Henry Formation, in gravel pit 3 miles northeast of Spring Grove (Fox Lake Quad.).

E - Thin Richland Loess overlying Yorkville Till Member of the Wedron Formation 1 mile south of Yorkville. The loess is clayey silt about 1 foot thick and has a sharp contact with the pebbly till below, at the head of the hammer.

F - Poorly sorted gravel in steeply dipping fore-set beds of an ice-front delta in Wasco Member of Henry Formation. Small gravel pit on the Rockdale Moraine on the north side of Romeoville (Romeoville Quad.).


A
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E
F

Haeger Till Member - The Haeger Till Member consists of yellow-gray, sandy or gravelly, silty till that occurs in the Valparaiso Morainic System in the westward bulge of the moraines north and west of Algonquin (figs. 16 and 17A) and along the front of the system southward, nearly to West Chicago (West Chicago Quad.). It is strikingly different from the Yorkville, Malden, and Tiskilwa Till Members, which it overlaps to the northwest. Along its east margin it is more clayey and is differentiated from the Wadsworth Till Member largely by its abundant gravel lenses and associated kames and eskers.

Wadsworth Till Member - The Wadsworth Till Member consists mostly of gray clayey till. It is the surface till in the Valparaiso Morainic System, the Tinley Moraine, and the Lake Border Morainic System, except in the northwestern part of the Valparaiso Morainic System where the gravelly till is differentiated as the Haeger Till Member. South of the area of the Haeger Till Member, the Wadsworth Till is not conspicuously different from the clayey till of the Yorkville Till Member that borders it on the west and south. However, the till in the West Chicago Moraine, the outermost of the Valparaiso Moraines, is slightly lighter in color, more silty, and contains more gravel lenses than the Yorkville till. The tills of the Lake Border Moraines, particularly in the area of Lake Chicago, have fewer pebbles, cobbles, and boulders than the older drifts. The Wadsworth Till contains an abundance of black shale from Mississippian and Devonian formations, both as pebbles and as finely ground particles in the matrix. The till in the Tinley Moraine has a particularly high content of black shale.

Morphostratigraphic Units

The deposits of the Woodfordian glaciers are also classified into morphostratigraphic units, called drifts, each of which consists of all the deposits related to the pulse of the ice front that produced a moraine. Each unit may contain parts of all of the formations of Woodfordian age except the Richland Loess. Each drift is named for the moraine on which it is based.

The Chicago area contains 27 named moraines (fig. 15). Nine of these are closely related moraines that form the Valparaiso Morainic System, and five make up the Lake Border Morainic System. Several of the named moraines may be contemporaneous. For example, the St. Charles and Marseilles Moraines are thought to be equivalent to the Huntley and Barlina Moraines. However, at least 19 stands of the ice front are required to account for the moraines in the Chicago area.

The moraines are grouped into seven map units on plate 1, but the boundaries of the individual moraines are shown and the units identified by different symbols. The individual moraines are all mapped and named in figure 16. The moraine map shows only the moraines on which the drifts are based, not the entire area covered by the drifts. The drifts are described below in units corresponding to those shown on plate 1.

Marengo Drift - The Marengo Drift is related to the Marengo Moraine, the oldest moraine in the area, the front of which lies west of the area. The moraine is one of the most prominent in the state. Its crest is locally as much as 200 feet above the outwash plain along its front. The drift is dominantly pink sandy till, but small kames and closed depressions that contain silt and peat are common on the surface. It is exposed in roadcuts in the Pingree Grove Quadrangle.

Gilberts and Elburn Drifts - The Gilberts Drift occurs in a rough, morainic area consisting of knobs, kettles, kames, eskers, and lake plains. Probably half of the deposits in the Gilberts Drift are waterlaid. The till is largely pinkish gray or yellow-gray. The Gilberts Drift was deposited by a glacier that advanced onto the back slope of the Marengo Moraine.

The Elburn Drift is probably contemporaneous with the Gilberts, but the till is yellow-gray and silty and it lacks the pinkish color common in the Gilberts till. The drift occurs in an irregular area mapped as the Elburn Complex because it consists of discontinuous, variously oriented, morainic ridges separated by pitted outwash, kames, eskers, and lake plains. The Kaneville Esker (Sugar Grove Quad.) is a prominent feature 6 miles long and 50 feet high, except where sand and gravel has been removed (Lukert and Winters, 1965).

St. Charles to Barlina Drifts - The St. Charles, Marseilles, Huntley, and Barlina Drifts are related to moraines that consist largely of gray clayey till. The Marseilles is one of the more prominent moraines in the state, but the other three are low, weakly morainic ridges. Outwash plains are abundant along the front of the Marseilles Moraine. The St. Charles Moraine is well developed immediately west of St. Charles in the Geneva Quadrangle. The Marseilles Moraine is prominent in the Platteville Quadrangle, and the Huntley and Barlina Moraines are distinct ridges in the Huntley Quadrangle.

Minooka to Manhattan Drifts - The Minooka, Rockdale, Wilton Center, and Manhattan Drifts are all related to moraines that are dominantly gray clayey till that is locally silty. The till is similar to, but generally less pebbly than, the Marseilles till. The Minooka is the most prominent of the moraines, and it overrides the Marseilles Moraine at right angles south of Aurora (Aurora South Quad.). These moraines have a low surface relief, and little outwash is associated with them. The Minooka Moraine is most prominently developed in the Aurora South and Yorkville Southeast Quadrangles, the Rockdale Moraine in the Plainfield and Joliet Quadrangles, and the Manhattan Moraine in the Manhattan Quadrangle.

Valparaiso Drifts - The nine moraines differentiated in the Valparaiso Moranic System (fig. 16) are closely spaced and appear to represent minor pulses of the ice front or perhaps only brief stands during the retreat. The boundaries between the moraines are indefinite in many places, and they have not been traced through the northeastern part of the area, which is mapped as undifferentiated Valparaiso. Only the West Chicago Moraine at the front of the morainic system is continuous. Because of uncertain correlations, some of the moraines that may be contemporaneous are given different names in different areas. The Cary Moraine is probably equivalent to the Wheaton, and the Palatine to the Clarendon.

The topography of the Valparaiso moraines is rough. Knobs, kettles, swamps, and lakes are particularly large and abundant in the northern part of the area. The area around Fox Lake is typical (Fox Lake and Antioch Quads.). The topography is more subdued and lakes are much less common in the southern part, where the area near Beecher is typical (Beecher East and Beecher West Quads.). The West Chicago Drift includes extensive outwash plains along the front of the moraine from Joliet northward. From Elgin northwestward the till is thin, overlies an extensive deposit of sand and gravel, and is mapped as thin till on gravel (pl. 1). In that area the till is yellow-gray, silty, and gravelly, whereas elsewhere it is mostly gray to light brownish gray clayey till. Prominent terraces of sand and gravel are traceable from the front of the morainic system down the Fox, Du Page, and Des Plaines Valleys.

Tinley Drift - The Tinley Drift is largely gray clayey till related to the Tinley Moraine. It represents a readvance of the ice onto the back slope of the Valparaiso Morainic System. The Tinley Moraine has a rough topography similar to that of the Valparaiso. Lake silts and clays as much as 20 feet thick accumulated in lakes along the front of the moraine (fig. 16). The Tinley Moraine is well developed in the Tinley Park Quadrangle.

Lake Border Drifts - The Lake Border Morainic System is well developed in the area north of Chicago (fig. 16). It consists of five moraines that are separated throughout much of their length by parallel valleys — the Des Plaines Valley and the valleys of tributaries of the Chicago River. Except near the Wisconsin state line, the Lake Border Moraines are much better defined than the moraines in the Valparaiso Morainic

System. The drift in all the moraines is a gray clayey till similar to that in most of the Valparaiso Moraines. The moraines have much less relief and gentler slopes than the Valparaiso Moraines. Kames, eskers, and lakes are scarce. Lake Border outwash consisting of fine sandy gravel was deposited along the Des Plaines Valley from its point of discharge into Lake Chicago northward to the state line (pl. 1). The four principal moraines in the system are well shown on the Highland Park Quadrangle, and the small patches of the Zion City Moraine are best shown on the Waukegan Quadrangle.

Woodfordian-Valderan Substages

Several of the formations that are dominantly Woodfordian in age continued to receive sediments through Twocreekan and Valderan time. These include the Henry Formation, a minor amount of which was deposited by the Chicago Outlet River during its discharge from Lake Algonquin of Valderan age. The Henry Formation may also include deposits made by the discharge from the Holocene lakes (Nipissing and Algoma), but it is more likely that these deposits are included in the Cahokia Alluvium. The Equality Formation likewise contains a small proportion of sediments that accumulated in Lake Algonquin and possibly in the Holocene lakes. The Richland Loess probably contains a small amount of wind-blown silt from Valderan outwash but very little has been added since then.

Henry Formation

The Henry Formation is glacial outwash, dominantly sand and gravel, that directly underlies the Modern Soil or the Richland Loess (Willman and Frye, 1970). In places the formation is overlain by Wisconsinan-Holocene formations. Sand and gravel outwash that underlies or is interbedded with till is included in the Wedron Formation.

The Henry Formation is subdivided into three members, the Wasco, Batavia, and Mackinaw Members, based on general differences in composition and sorting. The mapping of the members is based largely on topographic expression. They grade into each other in places, but in the stratigraphic classification they are never superimposed and are separated by a vertical cut-off. In addition to the extensive areas shown on plate 1, there are a great many areas of the Henry Formation too small to map. The formation is exposed in numerous gravel pits and roadcuts.

Wasco Member - The Wasco Member consists of sand and gravel deposited in or bordering the glaciers, most of it in kames, kame terraces, eskers, and deltas. These ice-contact deposits commonly contain lenses of till and silt, vary greatly in grain size and degree of sorting, and commonly have steeply dipping beds. The Wasco Member is exposed in numerous gravel pits, particularly near Wasco (Elburn Quad.) and in the Kaneville Esker (Sugar Grove Quad.).

Batavia Member - The Batavia Member consists of sand and gravel deposits in outwash plains, most of them along the front of the moraines. Those deposits close to the moraines have the poor sorting of the ice-contact deposits, but they do not have the disturbed bedding or the till content. The deposits of the Batavia Member are generally cross-bedded and become noticeably finer grained away from the moraine. They are upland deposits, but in some places they can be traced into valleys where they grade into the Mackinaw Member. Outwash plains are extensive along the front of the West Chicago Moraine north from Naperville, and the deposits are exposed in many gravel pits, particularly near Elgin and Crystal Lake (West Chicago, Elgin, and Crystal Lake Quads.).

Mackinaw Member - The Mackinaw Member consists of sand and gravel deposited by glacial rivers in the valleys. These deposits are generally better sorted, more evenly bedded, and more uniform in grain size than those of the other members. Because of repeated episodes of gravel deposition and erosion, the Mackinaw Member in some valleys consists of remnants of terraces at several levels. It also includes deposits by the outlet rivers of glacial lakes because these are similar in composition to the deposits of the glacial rivers. The Mackinaw Member is widely present in terraces along the Fox, Du Page, and Des Plaines Valleys, and typical exposures occur in gravel pits near Elgin, Plainfield, and Channahon (Elgin, Geneva, Normantown, Plainfield, and Channahon Quads.).

Equality Formation

The Equality Formation is composed of silt, sand, gravel, and clay deposits that accumulated in glacial lakes (Willman and Frye, 1970). It is generally overlain only by the thin Richland Loess or the Modern Soil, but in places it is overlain by the Wisconsinan-Holocene formations. In many of the areas mapped as Grayslake Peat, the Equality Formation underlies the peat and represents the initial filling of the lake basin immediately following the melting of the ice.

The Equality Formation is subdivided into two members — the Carmi Member, which is dominantly silt and clay, and the Dolton Member, which is dominantly sand and gravel. The members grade laterally into each other but are not superimposed. Although generally separable by a vertical cut-off in the gradational zone, members are not differentiated in areas where repeated lateral changes in composition occur or where the proportions of sand and silt are roughly equal.

The Equality Formation is almost continuously present in the areas mapped as Equality on plate 1, is common in patches throughout the areas mapped as lake plain, and is present at many places on the moraines in areas too small to map. The lake plains are flat, and the deposits are seldom exposed.

Carmi Member - The Carmi Member of the Equality Formation is dominantly silt, generally well bedded or laminated. Much of it is sandy, and it contains beds of fine sand and clay. In most of the lake basins these deposits are only a few feet thick, rarely as much as 20 feet thick. They underlie the flat areas of the lake basins and are the deeper water deposits. In the Chicago area they are exposed at the top of clay pits near Blue Island and Dolton (Blue Island and Lake Calumet Quads.).

Dolton Member - The Dolton Member of the Equality Formation is dominantly sand, but it contains beds of silt, pebbly sand, and gravel. The deposits are generally less than 10 feet thick, but in some of the more prominent spits they are as much as 25 feet thick. The Dolton Member consists of shore and shallow-water lake deposits, and it commonly occurs in low ridges that were beaches, bars, and spits. Pebbly sand and gravel is largely confined to narrow belts along the more prominent shorelines where waves eroded the till, washed away the silt and clay, and left a concentrate of sand and pebbles. The Dolton Member is exposed in sand pits in the Toleston beach at Dolton (Lake Calumet Quadrangle), in the Glenwood spit east of Chicago Heights (Calumet City Quad.), and in the Wilmette spit southwest of Wilmette (Evanston Quad.).

Richland Loess

The Richland Loess is a thin deposit of wind-blown silt that overlies the glacial drift (Wascher et al., 1960, fig. 9; Willman and Frye, 1970, pl. 3). The loess mantled the Chicago area soon after the glaciers melted, but much of it was washed by rains into the valleys and deposited in the Cahokia Alluvium. It is now present only on the flatter, uneroded upland areas. It is a fine-grained, clayey silt distinguished from the till below by much better sorting, lower clay content, and the absence of pebbles, except for a few probably mixed into it by burrowing animals (fig. 17E).

Because most of the loess in the Chicago area was blown from the Illinois and Mississippi Valleys during Woodfordian glaciation, it is thicker on the older drift in the western part of the area, where it started accumulating while the ice was still present in the area of the younger drift. The loess is 2 to 4 feet thick on the Marseilles Moraine; on the Lake Border Moraines it is generally less than a foot thick and is absent in many places. Although derived from the calcareous silt (glacial flour) deposited on the floodplains of the major rivers, the loess in the Chicago area is not calcareous. The carbonates probably were leached from the loess during its slow accumulation far from the source. The loess is weathered and is part of the Modern Soil. Where it is very thin, the loess is largely within the dark gray A-zone of the soil. Because it is so thin and irregularly distributed, the Richland Loess is not mapped on plate 1.

Wisconsinan and Holocene Stages

Deposition of some of the formations in the Chicago area began immediately following the melting of the glaciers and has continued to the present. These formations include the Parkland Sand, the Grayslake Peat, the Cahokia Alluvium, and the Lake Michigan Formation. They are surficial units and except for the older dunes of the Parkland Sand, generally have no cover of loess. The Modern Soil is developed directly on these deposits, except where they are actively accumulating at present. Because they are contemporaneous surficial units, they generally do not overlie each other. However, the Grayslake Peat and the Parkland Sand are locally present on the floodplains of major rivers, where they overlie the Cahokia Alluvium.

Parkland Sand

The Parkland Sand consists of well sorted, medium-grained sand that was blown from the glacial outwash or from beach deposits of lakes into dunes and sheet-like deposits around the dunes (Willman and Frye, 1970). The most extensive areas of Parkland Sand in the Chicago area are along the Kankakee Valley south of Wilmington (Wilmington and Symerton Quads.), where many dunes are 20 to 30 feet high and some are 50 feet high (Willman, 1942). Parkland Sand also occurs on some of the Lake Chicago beach ridges, such as the Toleston beach at Dolton (Lake Calumet Quad.) and the west side of the Thornton klint (reef) east of Homewood (Harvey Quad.). The sand is generally brown and well bedded. Except in the few blowouts, the dunes are largely forested, and most of them were stabilized in their present positions soon after they formed. A few dunes border the Lake Michigan Beach near Zion.

Grayslake Peat

The Grayslake Peat occurs in areas bordering existing lakes or in depressions that previously were lake basins (Hester and Lamar, 1969; Willman and Frye, 1970) (fig. 23C). The depressions are very abundant — literally hundreds occur in the morainal areas. The Grayslake Peat, although dominantly peat, includes organic silts (muck) and contains interbedded silts and sands that represent local slopewash into the basins. Some of the deposits contain beds of marl consisting largely of small shells, mostly gastropods and pelecypods. The Grayslake Peat is generally less than 20 feet thick. It probably is thicker in some of the larger areas but in many areas it is less than 5 feet thick. The mapping of the Grayslake Peat is based largely on soil maps and on the swampy areas shown on the topographic maps. A great many depressions that contain peat are too small to be mapped on plate 1, but in places several small closely spaced deposits are mapped as units. The peat is exposed where the weight of the road fill has caused the peat to heave along some of the roads crossing bogs, and it can also be seen in excavations where it is dug for horticultural purposes (fig. 24).

Cahokia Alluvium

The Cahokia Alluvium consists largely of sandy silt that was deposited on the floodplains of streams and rivers. It was called Recent Alluvium in earlier reports (Willman and Frye, 1970). The alluvium generally is poorly sorted and irregularly bedded, and it contains lenses of sand and gravel, particularly in the lower part. The alluvium is largely sand and gravel at the mouths of many tributary valleys and in bars along the present channels. Much of the alluvium is derived by slopewash from weathered surfaces and is generally noncalcareous, in which respect it differs from the calcareous deposits of glacial rivers in this region. Along the margins of the floodplains the alluvium grades into slopewash deposits that form a discontinuous belt too narrow to map on plate 1. They are included in the Cahokia Alluvium.

Lake Michigan Formation

The Lake Michigan Formation consists of the surficial deposits that accumulate in modern lakes and in beaches along their shores (Willman and Frye, 1970). Although most extensively developed in Lake Michigan, the formation is present in nearly all existing lakes. It consists largely of silt and clay, but sand and gravel reworked from glacial deposits is abundant locally (Gross et al., 1970). The only part of the formation readily accessible for study is the sand on the modern beaches, which is differentiated as the Ravinia Sand Member (fig. 23A). In the Chicago area the beaches are too narrow to map on plate 1. Drilling in the bottom sediments of Lake Michigan has shown the lateral continuity of distinctive beds of clay and silt, and they are differentiated as members of the Lake Michigan Formation (Lineback, Ayer, and Gross, 1970). Because a lake has been continuously present since Lake Chicago formed against the front of the retreating glacier, sedimentation has been continuous since Woodfordian time. The Lake Michigan Formation, therefore, is in part contemporaneous with the Equality Formation.

Holocene Stage

The Parkland Sand, Grayslake Peat, Cahokia Alluvium, and Lake Michigan Formation are accumulating at present, but in most localities the greater parts of these formations are Wisconsinan in age. In all four formations, however, some individual deposits may be entirely Holocene. A few dunes in the Parkland Formation have migrated onto other formations during Holocene time. In some lakes the peat stage of filling did not begin until Holocene time. Along some valleys the alluvial fill spread onto older formations during the Holocene, and in other valleys the streams were dominantly eroding until Holocene time. In Lake Michigan, Holocene deposits partially cover shallow areas, such as the bedrock highs, that are subject to scour by waves.

Other deposits entirely of Holocene age are those made by man (Willman and Frye, 1970). The strip-mine waste piles and made-land along Lake Michigan cover areas large enough to map on plate 1. Others, such as highway and refuse landfills, cover large areas but individually are too small to show on the map.

<u>Strip-mine waste piles</u> - The waste piles of the coal strip mines cover many square miles in Grundy and Will Counties (Lisbon, Morris, Coal City, and Wilmington Quads.). The waste piles are steep-sloped ridges consisting of mixtures of the bedrock and glacial materials that were stripped from the coal. Shale and till dominate, but fragments of the more resistant materials — sandstone, slate, and concretions from the bedrock, and cobbles and boulders of dolomite and of igneous and metamorphic rocks from the glacial drift — become concentrated on the steeper slopes as the softer materials are washed away. Some older strip-mine waste piles have been reforested and are used as recreation areas. Others have been flattened and returned to a condition suitable for agriculture and other purposes.

<u>Made-land</u> - The made-land (pl. 1) consists of areas that were formerly lake bottom but have been made into land by various methods—building piers to trap sand that is carried by currents along the shore; pumping sand from deeper water; transporting sand by barge from other areas; and dumping mixtures of various materials from the land. The made-land along Lake Michigan is mostly sand. A typical area is Northerly Island, on which Meigs Field is located (Jackson Park Quad.). The made-land along Lake Calumet (Lake Calumet Quad.) is largely rubbish from the cities.

GLACIAL HISTORY

Pre-Wisconsinan Ages

At the beginning of the Pleistocene Epoch, the Chicago area was probably an upland plain underlain by a thick soil developed on the Paleozoic rock formations. Valleys were not deeply eroded, although a northward-flowing river may have been entrenched in the belt of shales on the northeast flank of the Kankakee Arch in the area now occupied by Lake Michigan. The Pennsylvanian rocks probably extended much farther north than they do now and overlapped Ordovician and Silurian formations.

The earliest definitely established glaciation of the Chicago area was during the Illinoian Age (fig. 18.) Although no Illinoian deposits have been identified in the area, Illinoian glacial deposits to the northwest, west, and southwest (fig. 2) could have been deposited only by a Lake Michigan Lobe glacier that crossed the Chicago area. Deposits of the immediately preceding glaciation, the Kansan, occur in the La Salle and Ottawa area and might have been deposited by a glacier that crossed the Chicago area, but eastern Kansan drift farther south was deposited by an Erie Lobe glacier that advanced from the east. Although no evidence of a Lake Michigan Lobe glacier during the Kansan has been found, a Kansan glacier could have eroded the basin that later caused the Illinoian glacier to form a prominent lobe. The erosion by the younger Wisconsinan glacier was so severe that the Illinoian drift was almost entirely eroded, and the probability is slight that Kansan or still older Nebraskan drift is preserved.

Glacial erosion, and some stream erosion during both glacial and interglacial ages, may well have stripped 100 to 200 feet of bedrock formations from the Chicago area. During the Sangamonian interglacial age (2, fig. 18), immediately preceding the Wisconsinan glaciation, a thick soil developed over the area. Although widely preserved beneath the Wisconsinan glacial drift near the margin of the drift, the soil was completely stripped from the Chicago area by the Wisconsinan glaciers.

Wisconsinan Age

Altonian Time

The Altonian glacier, the earliest of the Wisconsinan glaciers, advanced southward into the Lake Michigan Basin, overflowed the basin, and spread westward across the Chicago area (3, fig. 18). As the ice front retreated, the glacier deposited the Winnebago drift, which is encountered in drill holes and locally in stream valleys. Evidence in other areas indicates that the Altonian glacier probably arrived in the Chicago area about 60,000 radiocarbon years ago. Several advances and retreats occurred before the end of Altonian time, about 28,000 radiocarbon years ago.

Farmdalian Time

The glaciers retreated entirely from the Chicago area during Farmdalian time, but remnants of a cold-climate vegetation in the Robein Silt suggest that the ice may not have melted entirely from the Lake Michigan Basin. The Farmdalian interval of ice withdrawal extended from about 28,000 to 22,000 radiocarbon years ago, and during it the Robein Silt, an organic silt or peat, accumulated on the Altonian drift. Weathering of the silt and underlying deposits formed the Farmdale Soil. The silt and soil have been widely eroded but are locally present in the subsurface.

Wood found in lake silts exposed 1 mile north of Morris is 24,000 radiocarbon years old, and the silts were probably deposited in a lake dammed by Altonian moraines.

Woodfordian Time

Most of the glacial drift in the Chicago area was deposited during Woodfordian time. It was the time of maximum Wisconsinan glaciation (4, fig. 18), and it lasted

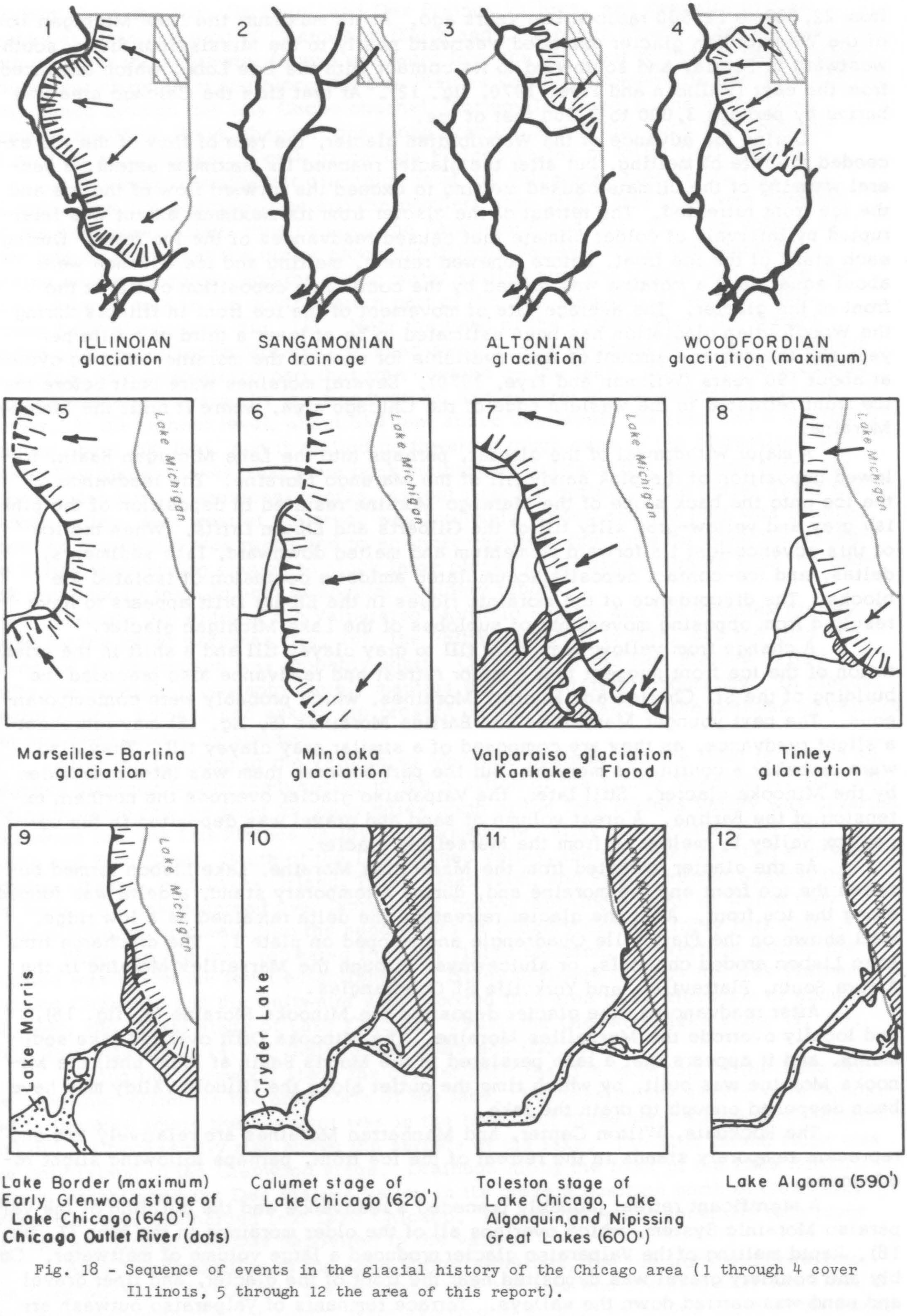


Fig. 18 - Sequence of events in the glacial history of the Chicago area (1 through 4 cover Illinois, 5 through 12 the area of this report).

from 22,000 to 12,500 radiocarbon years ago. At its maximum the Lake Michigan Lobe of the Woodfordian glacier extended westward nearly to the Mississippi River, southwestward to Peoria, and southward to its contact with the Erie Lobe, which advanced from the east (Willman and Frye, 1970, fig. 12). At that time the Chicago area was buried by perhaps 3,000 to 5,000 feet of ice.

During the advance of the Woodfordian glacier, the rate of flow of the ice exceeded the rate of melting, but after the glacier reached its maximum extent, a general warming of the climate caused melting to exceed the forward flow of the ice and the ice front retreated. The retreat of the glacier from its maximum extent was interrupted by intervals of colder climate that caused readvances of the ice front. During each stand of the ice front, before renewed retreat, melting and ice advance were about equal, and a moraine was formed by the continuing deposition of till at the front of the glacier. The average rate of movement of the ice front in Illinois during the Woodfordian glaciation has been estimated to be at least a third of a mile per year and the average amount of time available for each of the moraine-building cycles at about 190 years (Willman and Frye, 1970). Several moraines were built before the ice front retreated to the western edge of the Chicago area, where it built the Marengo Moraine.

A major withdrawal of the glacier, perhaps into the Lake Michigan Basin, followed deposition of the pink sandy till of the Marengo Moraine. The readvance of the ice onto the back slope of the Marengo Moraine resulted in deposition of the pinkish gray and yellow-gray silty till of the Gilberts and Elburn Drifts. When the ice of this advance lost its forward momentum and melted downward, lake sediments, deltas, and ice-contact deposits accumulated amidst a confusion of isolated ice blocks. The discordance of the morainic ridges in the Elburn Drift appears to have resulted from opposing movements of sublobes of the Lake Michigan glacier.

A change from yellow-gray silty till to gray clayey till and a shift in the orientation of the ice front suggest that a major retreat and readvance also preceded the building of the St. Charles and Huntley Moraines, which probably were contemporaneous. The next younger Marseilles and Barlina Moraines (5, fig. 18) may represent a slight readvance, as they are composed of a similar gray clayey till. They also were probably a continuous moraine, but the part between them was later overridden by the Minooka glacier. Still later, the Valparaiso glacier overrode the northern extension of the Barlina. A great volume of sand and gravel was deposited in the upper Fox Valley by meltwater from the Marseilles glacier.

As the glacier retreated from the Marseilles Moraine, Lake Lisbon formed between the ice front and the moraine and, during a temporary stand, a delta was formed along the ice front. After the glacier retreated, the delta remained as a low ridge, well shown on the Platteville Quadrangle and mapped on plate 1. The discharge from Lake Lisbon eroded channels, or sluiceways, through the Marseilles Moraine in the Aurora South, Platteville, and Yorkville SE Quadrangles.

After readvancing, the glacier deposited the Minooka Moraine (6, fig. 18), and locally overrode the Marseilles Moraine. The Minooka Drift overlies lake sediments, and it appears that a lake persisted in the Morris Basin at least until the Minooka Moraine was built, by which time the outlet along the Illinois Valley may have been deepened enough to drain the lake.

The Rockdale, Wilton Center, and Manhattan Moraines are relatively low and represent temporary stands in the retreat of the ice front, perhaps following slight readvances.

A significant retreat probably preceded a readvance and the building of the Valparaiso Morainic System, which overlaps all of the older moraines in the area (7, fig. 18). Rapid melting of the Valparaiso glacier produced a large volume of meltwater. Cobbly and bouldery gravel was deposited near the front of the glacier, and finer gravel and sand was carried down the valleys. Terrace remnants of Valparaiso outwash are abundant along the Fox, Du Page, and Des Plaines Valleys, and deposits in high terraces at Elgin and east of Channahon (Elgin and Channahon Quads.) are typical. North of Joliet the meltwater flowed westward from the ice front to the Du Page Valley through four channels — one along the Des Plaines Valley to Romeoville and then directly ahead through the Lily Cache channel (Romeoville Quad.); one along Long Branch to the Mink Creek channel; one along Fraction Run to the Rock Run channel; and another along Hickory Creek to the Des Plaines Valley at Joliet (Joliet Quad.).

At the peak of meltwater discharge from the Valparaiso glacier (7, fig. 18), meltwater from the Saginaw Lobe and the northern side of the Erie Lobe was diverted into the Kankakee Valley, thus causing the Kankakee Flood (fig. 2). The volume of water was so great that the outlet along the Illinois Valley through the Marseilles Moraine was inadequate, and the rising water spilled over the upland behind the moraine. A large area in the southwestern part of the map area (pl. 1) was flooded, forming Lake Wauponsee (fig. 16). Near the head of the Illinois River the waters flooded over the Minooka Moraine, washed away a large segment of it, and smoothed the surface of the remaining part that was covered by the lake. Much of the Rockdale Moraine was also covered by the floodwaters, but several higher segments became islands. At its highest level, about 650 feet above sea level, the lake had a maximum depth of about 100 feet, and it spilled northward through gaps in the Marseilles Moraine. The highest level must have been maintained only briefly, because there are no beach deposits or erosional scarps, except near the outlets. The outlet along the Illinois Valley, just west of the area, was intensely eroded and the lake was lowered. When the floodwater was restricted to an inner channel, the currents down the Kankakee Valley were strong enough to pluck large blocks of Silurian dolomite from the bedrock and deposit them in bars of angular bouldery rubble.

Despite the width of the Valparaiso Morainic System and the complex history shown by the minor moraines (fig. 16), the Valparaiso Drift is thin, and the time required for its deposition was probably short. On and near the Des Plaines Valley bluffs the morainic topography merely mantles the pre-existing topography. In places, glacial knobs, kames, and eskers are present on the walls and in the bottoms of valleys that had been eroded by streams.

After the building of the Valparaiso Morainic System, the ice front retreated an unknown distance before readvancing to the position of the Tinley Moraine (8, fig. 18). Drainage along the ice front for many miles north of the Des Plaines Valley was diverted southward into the Des Plaines Valley and formed the valley now occupied by Salt Creek and Flag Creek. South of the Des Plaines Valley, the ice front blocked eastward-flowing streams, and Lakes Orland, Tinley, Matteson, and Steger formed against the ice front. The lakes spread over large areas before reaching a level at which they could discharge westward into the headwaters of Hickory Creek (Tinley Park Quad.).

When the ice front retreated from the Tinley Moraine, the surface behind the moraine was below the level established by Tinley drainage through the Des Plaines and Sag Channels and the meltwater soon flooded this area to an elevation of about 640 feet, the initial stage of Lake Chicago, called the Glenwood lake stage (9, fig. 18). This was about 14,000 radiocarbon years ago (fig. 19).

During the Glenwood stage the glacier built the five moraines of the Lake Border Morainic System in the area north of the lake. Successive till sheets were deposited in the area where the ice front was in the lake, but these were submerged features and did not necessarily rise above the surface of the lake. The Blue Island ridge was the only island in the Glenwood stage. Drainage along the front of the Lake Border glacier established the Des Plaines Valley in its present position north of Oak Park, where the river discharged into Lake Chicago. An extensive but generally thin layer of sand and fine gravel was deposited in the valley.

After the deposition of the Lake Border Moraines, the ice front withdrew into the Lake Michigan Basin, and the Highland Park Moraine and the Zion City Moraine, if the latter extended that far south, were exposed to erosion by waves north of Winnetka at a position now out in the lake. Sand and fine gravel eroded from the cliffs was carried southward by the longshore currents, and the many-fingered Wilmette spit (pl. 1) (Park Ridge and Evanston Quads.) was built into the deeper water (Bretz, 1939, p. 108). Spits also were built into the Glenwood stage lake at Oak Park (River Forest Quad.), La Grange (Hinsdale Quad.), Blue Island (Blue Island Quad.), and Homewood (Harvey Quad.), and a very large spit was formed at Glenwood (Calumet City Quad.).

After passing through the Valparaiso Morainic System, the Chicago Outlet River at first flowed through the Lily Cache Slough to the Du Page Valley, but near Romeoville it flooded over the divides to the south and established the Des Plaines River in its present position. The Chicago Outlet River flooded the Morris Basin to an elevation of about 560 feet and formed Lake Morris, which had a maximum width of nearly 10 miles. The lake persisted long enough to establish an erosional shoreline on both sides of the Illinois Valley.

Interbedded silt and sand deposited in Lake Morris was highly deformed in places by the growth of ice wedges, which indicates that permafrost developed locally (Sharp, 1942). The intricate permafrost structures, called involutions, were well exposed by strip mining 2 miles northeast of Coal City (Coal City Quad.), but the principal exposures were destroyed by the mining. Such features are not common in the region, although they also occur in the Glenwood spit east of Chicago Heights (Frye and Willman, 1965). The permafrost at both localities probably developed after the Glenwood stage of Lake Chicago.

A great influx of water from lakes in the Huron and Erie Basins flowed through the Grand River Valley across central Michigan and into Lake Chicago about 13,000 radiocarbon years ago, eroded the Chicago Outlet about 20 feet, and lowered the level of Lake Chicago to about 620 feet above sea level — the Calumet lake stage (10, fig. 18; Calumet I, fig. 19). The area of Lake Chicago was considerably reduced. Blue Island was connected by land to Mt. Forest Island, and Worth Island appeared (Palos Park and Blue Island Quads.). A prominent, almost continuously traceable shoreline was eroded, and well defined beaches, such as the Lansing beach (Calumet City Quad.), were formed. A Calumet stage beach is also preserved north of Waukegan (Waukegan Quad.).

In the Morris Basin a broad expansion of the Chicago Outlet River, called Cryder Lake, entrenched itself about 20 feet and eroded a steep-sloped escarpment, the top of which has an elevation of 540 feet. In the relatively soft glacial deposits, the river cut a channel as much as 6 miles wide. This erosional surface is mapped as a glacial sluiceway along the Illinois Valley (pl. 1). Much of the deepening and widening of the outlet from Sag Bridge to Joliet was through bedrock. Coarse cobbly gravel, dominantly Silurian dolomite, was deposited in the channel and is preserved in benches along the Des Plaines Valley at Lockport and Joliet (Joliet Quad.), at Channahon (Channahon Quad.), and at Morris (Morris Quad.). These deposits form a large part of the Henry Formation along the Des Plaines Valley below Lockport and along the Illinois River (pl. 1). The interval during which coarse gravel was deposited persisted long enough for dolomite cobbles 5 to 6 inches in diameter to be carried down the Illinois Valley as far as Ottawa. Some of these gravel deposits were reworked during succeeding high-water stages of the Chicago Outlet River.

When the glacier of the Lake Michigan Lobe retreated northward beyond the Straits of Mackinac, an eastward outlet for Lake Chicago was established and the lake was lowered below the level of the present lake. This marked the end of Woodfordian glaciation.

Twocreekan Time

The low stage of Lake Chicago (fig. 19) is indicated by the forest bed at Two Creeks, Wisconsin, which is thought to correlate in the Chicago area with a bed of peat exposed during excavation of the North Shore Channel south of Devon Avenue

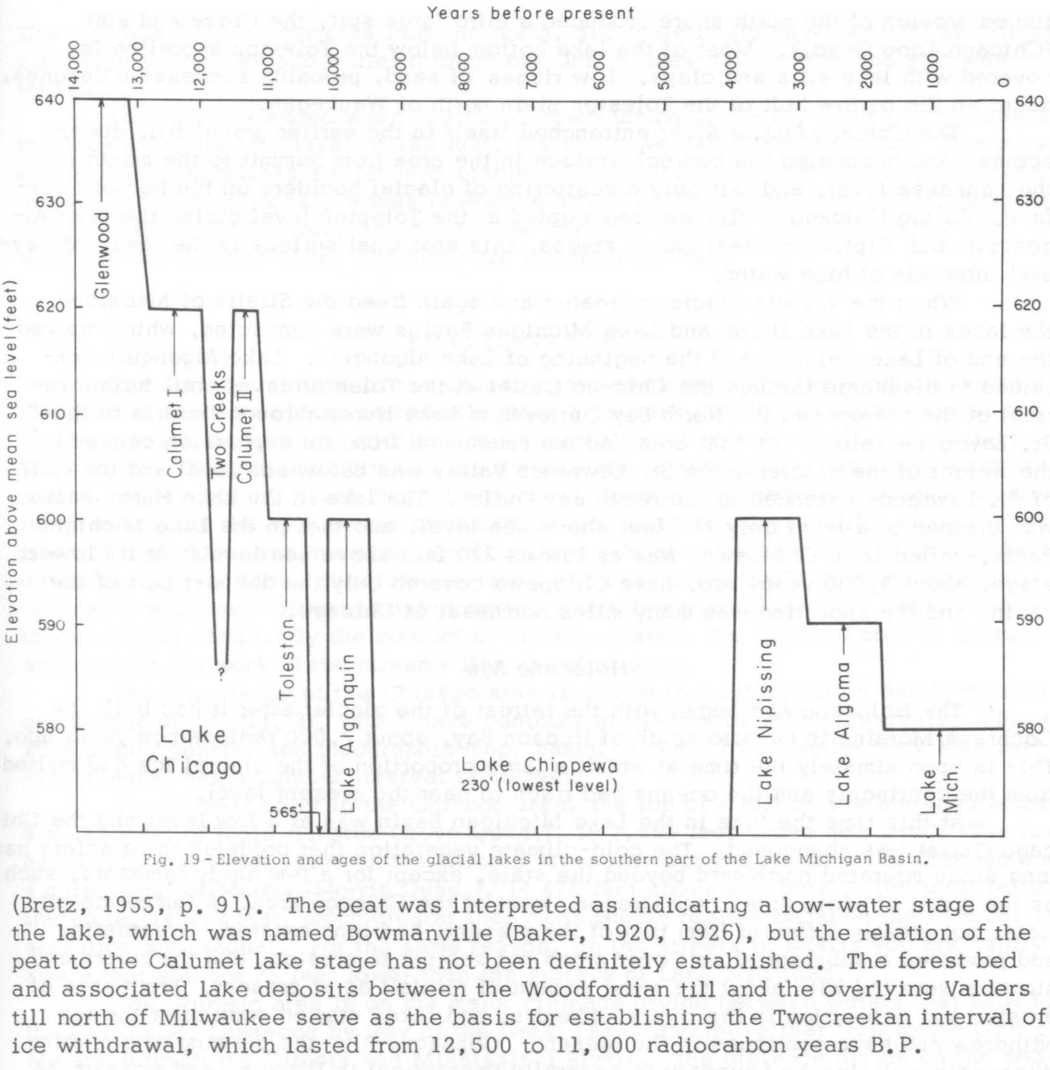


Fig. 19 - Elevation and ages of the glacial lakes in the southern part of the Lake Michigan Basin.

(Bretz, 1955, p. 91). The peat was interpreted as indicating a low-water stage of the lake, which was named Bowmanville (Baker, 1920, 1926), but the relation of the peat to the Calumet lake stage has not been definitely established. The forest bed and associated lake deposits between the Woodfordian till and the overlying Valders till north of Milwaukee serve as the basis for establishing the Twocreekan interval of ice withdrawal, which lasted from 12,500 to 11,000 radiocarbon years B.P.

Valderan Time

When the Lake Michigan Lobe glacier readvanced, it again blocked the outlet of the lake at the Straits of Mackinac, and Lake Chicago returned to the 620-foot Calumet level and again discharged through the Chicago Outlet (Calumet II, fig. 19). During the Calumet stage, erosion of the north shore continued. From the south end of the cliffs, at a position now out in Lake Michigan, the large Rose Hill spit was built (Evanston and Chicago Loop Quads.). Spits also were built into the lake at Riverside (Berwyn Quad.) and east of Blue Island (Blue Island Quad.).

Continued erosion of the outlet, probably because of further diversion of waters from the Huron Basin into Lake Chicago, resulted in lowering the lake to a level of about 600 feet, where the Toleston stage beach, the lowest of the three prominent shorelines, was formed about 11,500 years ago (fig. 19). The Valders glacier was at its maximum advance, reaching nearly to Milwaukee on the land and farther south in the central part of the lake. The glacier deposited a distinctive red till, and beyond the ice front, beds of red clay were deposited in the lake.

At the Toleston stage (11, fig. 18) the area of Lake Chicago in the Chicago Lake Plain was reduced to about half the area covered in the Glenwood stage. Continued erosion of the north shore produced a third large spit, the Graveland spit (Chicago Loop Quad.). Most of the lake bottom below the Toleston shoreline is covered with lake silts and clays. Low ridges of sand, probably successive beaches, occur on the narrow belt of the Toleston plain north of Waukegan.

The Chicago Outlet River entrenched itself in the earlier gravel fill, deeply scoured and channeled the bedrock surface in the area from Summit to the mouth of the Kankakee River, and left only a scattering of glacial boulders on the bedrock surface. As the Chicago Outlet was reoccupied at the Toleston level during the Lake Algonquin and Nipissing Great Lakes stages, this erosional surface is the result of several intervals of high water.

When the Valders glacier retreated and again freed the Straits of Mackinac, the lakes in the Lake Huron and Lake Michigan Basins were connected, which marked the end of Lake Chicago and the beginning of Lake Algonquin. Lake Algonquin continued to discharge through the Chicago Outlet at the Toleston level until further retreat of the ice opened the North Bay Outlet from Lake Huron through Ontario to the St. Lawrence Valley. As that area had not rebounded from the depression caused by the weight of the glaciers, the St. Lawrence Valley was below sea level and the Gulf of St. Lawrence extended to the North Bay Outlet. The lake in the Lake Huron Basin was drained to a level only 180 feet above sea level, and that in the Lake Michigan Basin, called Lake Chippewa, was as low as 230 feet above sea level. At its lowest stage, about 9,000 years ago, Lake Chippewa covered only the deepest part of the basin, and the shoreline was many miles northeast of Chicago.

Holocene Age

The Holocene Age began with the retreat of the glacier after it had built the Cochrane Moraine in Ontario south of Hudson Bay, about 7,000 radiocarbon years ago. This is approximately the time at which a large proportion of the glacial ice had melted from the continents and the oceans had risen to near the present level.

At this time the lake in the Lake Michigan Basin was at a low level and the Chicago Outlet was abandoned. The cold-climate vegetation that bordered the glaciers had long since migrated northward beyond the state, except for a few hardy remnants, such as the grove of white pines near Oregon, west of the Chicago area. A temperate climate, not greatly different from that of the present, had long existed. Weathering had produced a substantial soil over areas not subject to erosion, and the rivers and streams were fed with about the same amount of rainfall as at present. Processes of erosion and deposition in the rivers, streams, and lakes started soon after the ice withdrew and have continued to the present. Consequently, the drawing of a precise Wisconsinan-Holocene boundary is generally impractical in Illinois, and most of the post-glacial deposits are assigned a Wisconsinan-Holocene age.

During the Holocene the Chicago area was affected by the continued retreat of the ice front and the uplift of the North Bay Outlet area in Ontario. When this outlet was closed, the lakes in the Lake Michigan and Lake Huron Basins rose again to the level of the Toleston beach and discharged through two outlets — the Chicago Outlet and the St. Clair Outlet to Lake Erie at Detroit. These were the Nipissing Great Lakes (fig. 19), which existed from about 4,000 to 3,000 years ago. The St. Clair Outlet, which was in till, was rapidly eroded, and the lake was lowered about 10 feet. The Chicago Outlet, which was in bedrock, was eroded more slowly, and it was abandoned.

Lake Algoma (fig. 19) existed at a level of 590 feet from about 3,000 to 2,000 years ago, and it probably temporarily had a small discharge through the Chicago Outlet because the north end of the lake was uplifted more rapidly than the south end (12, fig. 18). In either the Nipissing Great Lakes or Lake Algoma, a complex of low sand bars, tongues of a spit, was built southward and successively eastward into the lake south of Jackson Park (Jackson Park and Lake Calumet Quads.), as shown on plate 1.

The spit was built by currents from the north, and there could have been no significant discharge to the Chicago Outlet through the Des Plaines Valley when the spit was formed.

Lake Algoma ended when continued downcutting of the St. Clair Outlet lowered the lake to its present level of 580 feet, the stage we call Lake Michigan. The present lake and shorelines are far from stable. During intervals when the lake is a foot or two higher than normal, waves renew the attack on the north-shore cliffs, despite many protective structures, and during low-water stages the shorelines move outward and the smaller docks and piers are left high and dry.

PHYSIOGRAPHY

The surface features of the Chicago area are largely the result of glaciation. The glacial deposits almost completely mask a bedrock surface on which glacial and stream erosion produced a relief and roughness at least comparable to that of the present surface. The major features of the surface are depositional — moraines, outwash plains, valley trains, filled lake basins, river floodplains, and sand dunes. Erosional features include the sluiceways produced by glacial floodwaters, cliffs along the shorelines of the lakes, and numerous small valleys that streams have eroded in the glacial deposits. The surface, therefore, in terms of an erosional cycle, is very youthful. Compared with much older glaciated areas, where few glacial features remain and the topography is dominantly the product of stream erosion, the Chicago area is uneroded and most of the work of the streams lies ahead of them.

The topography of the Chicago area is shown in most detail on the $7\frac{1}{2}$-minute quadrangle maps (fig. 3), which have contours at 10-foot or 5-foot intervals. Figure 20, a highly generalized topographic map, based on the 1 by 2 degree Army Map Service sheets, has a contour interval of 50 feet.

The highest point in the Chicago area, the top of a hill on the Marengo Moraine 6 miles west of Elgin (Pingree Grove Quad.), is 1,065 feet above sea level. The lowest point, low-water stage on the Illinois River where it passes from the Chicago area, 4 miles west of Morris (Morris Quad.), is 475 feet above sea level. The total relief, therefore, is 590 feet, much greater than most people realize because the changes in elevation are gradual. For the same reason, on the streets in Morris you are hardly aware that you are 75 feet lower than the surface of Lake Michigan.

The Chicago area is on the major drainage divide between waters that flow to the Gulf of St. Lawrence by way of the Great Lakes and those that flow to the Gulf of Mexico through the Illinois and Mississippi Rivers. The drainage divide on the bedrock surface (fig. 21) lies west of the divide on the present surface, and it influences the subsurface drainage.

Each of the glaciations probably shifted the drainage divide. During Wisconsinan glaciation and much of Lake Chicago time, the drainage of the entire area was to the Mississippi River. When the outlet of the Great Lakes was opened to the east, the present divide was established (fig. 21). The Des Plaines River had taken a course across the lake plain to the Chicago Outlet, and only the Chicago and Calumet Rivers flowed into Lake Michigan. Since the establishment of locks at the mouth of the Chicago River to control diversion from Lake Michigan to the Chicago Sanitary and Ship Canal, the Chicago River has been diverted through the canal to the Des Plaines Valley, except during major floods (fig. 21). A small area of the Calumet River drainage in Illinois also is diverted by locks through the Calumet Sag channel to the Des Plaines Valley. The diversions made by man reduce the area of drainage into Lake Michigan.

CENTRAL LOWLAND PROVINCE

The Chicago area is in the central part of the Central Lowland Province (Leighton, Ekblaw, and Horberg, 1948), a broad, relatively low area that roughly outlines the

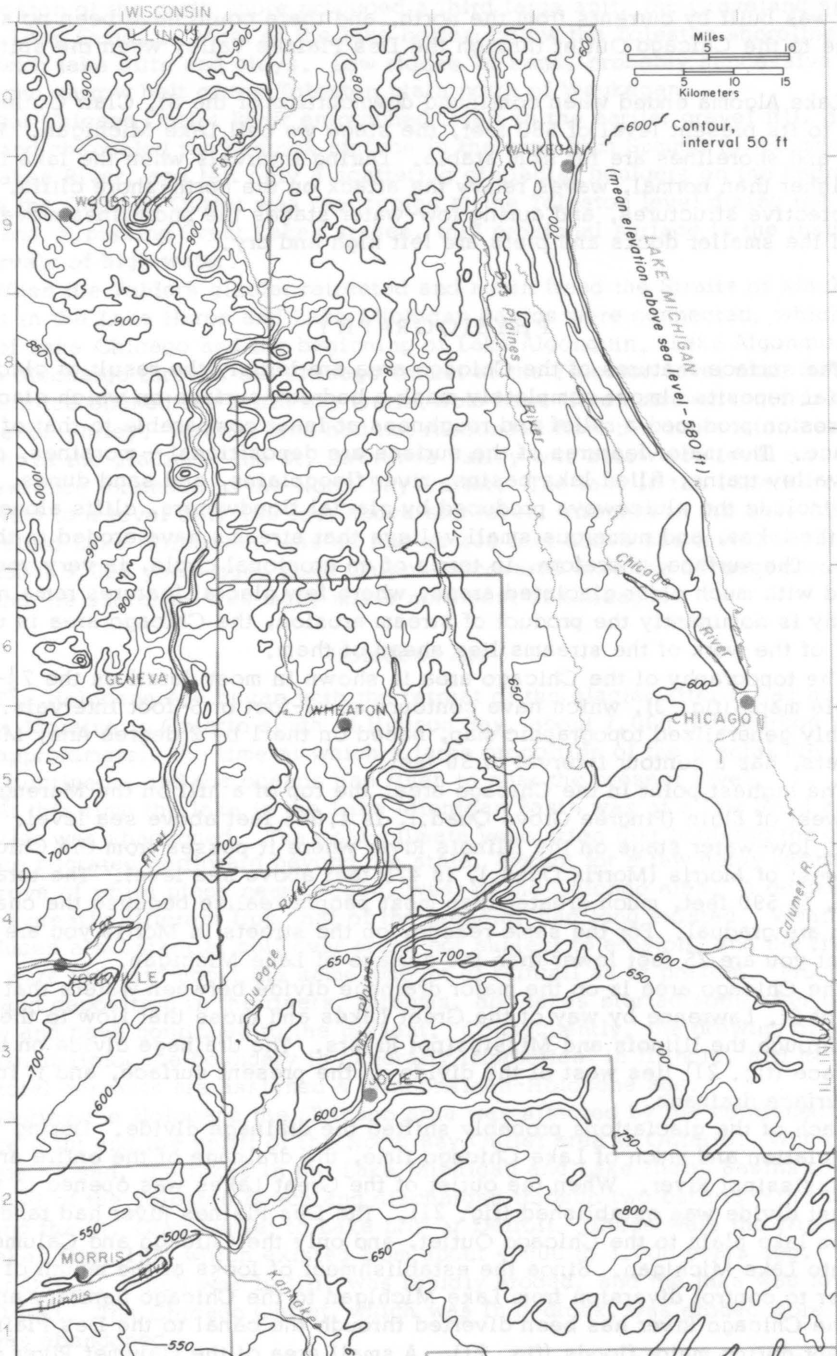


Fig. 20 - Generalized topography of the Chicago area (from Army Map Service maps of the Rockford, Racine, Aurora, and Chicago sheets).

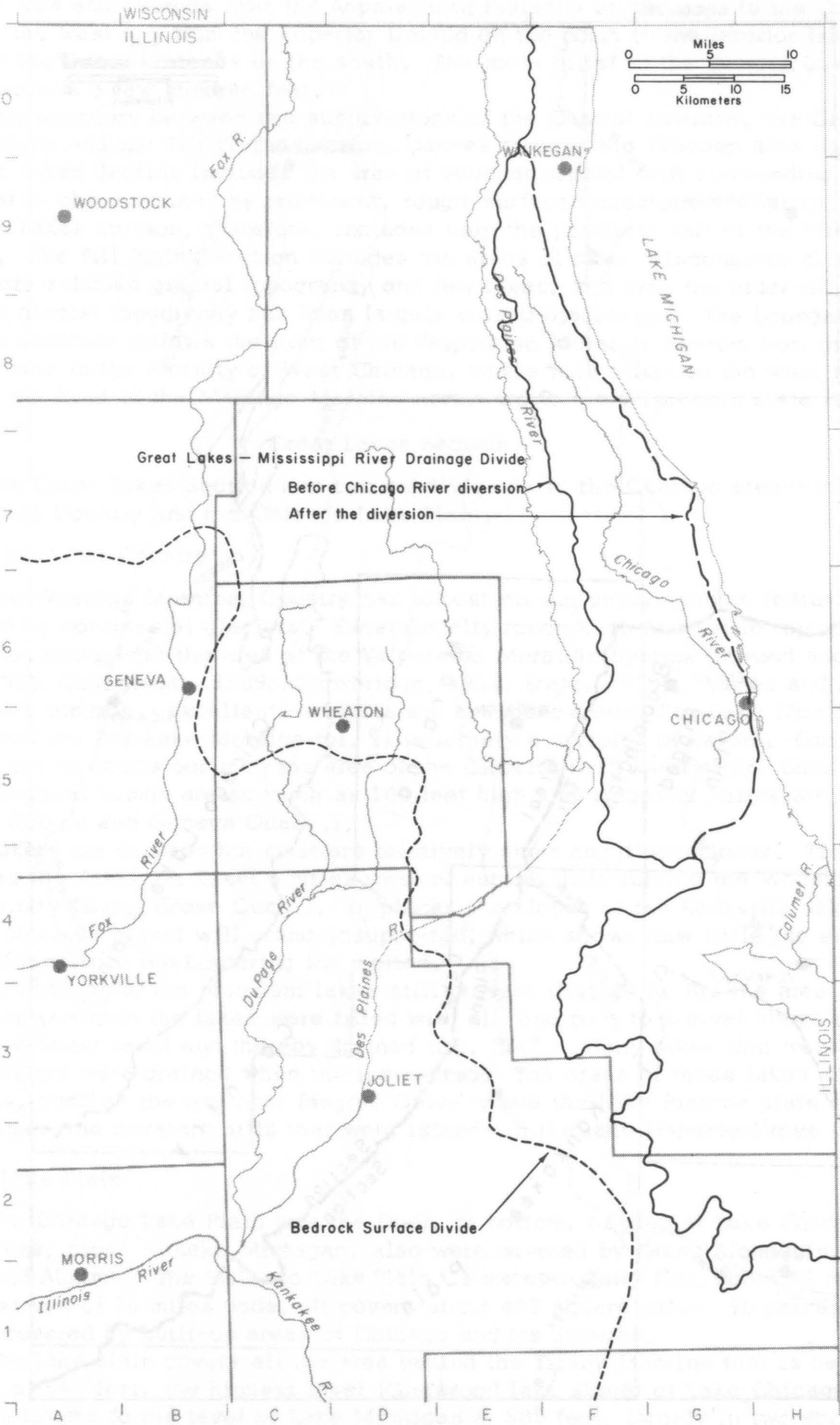


Fig. 21 - Drainage divides in the Chicago area.

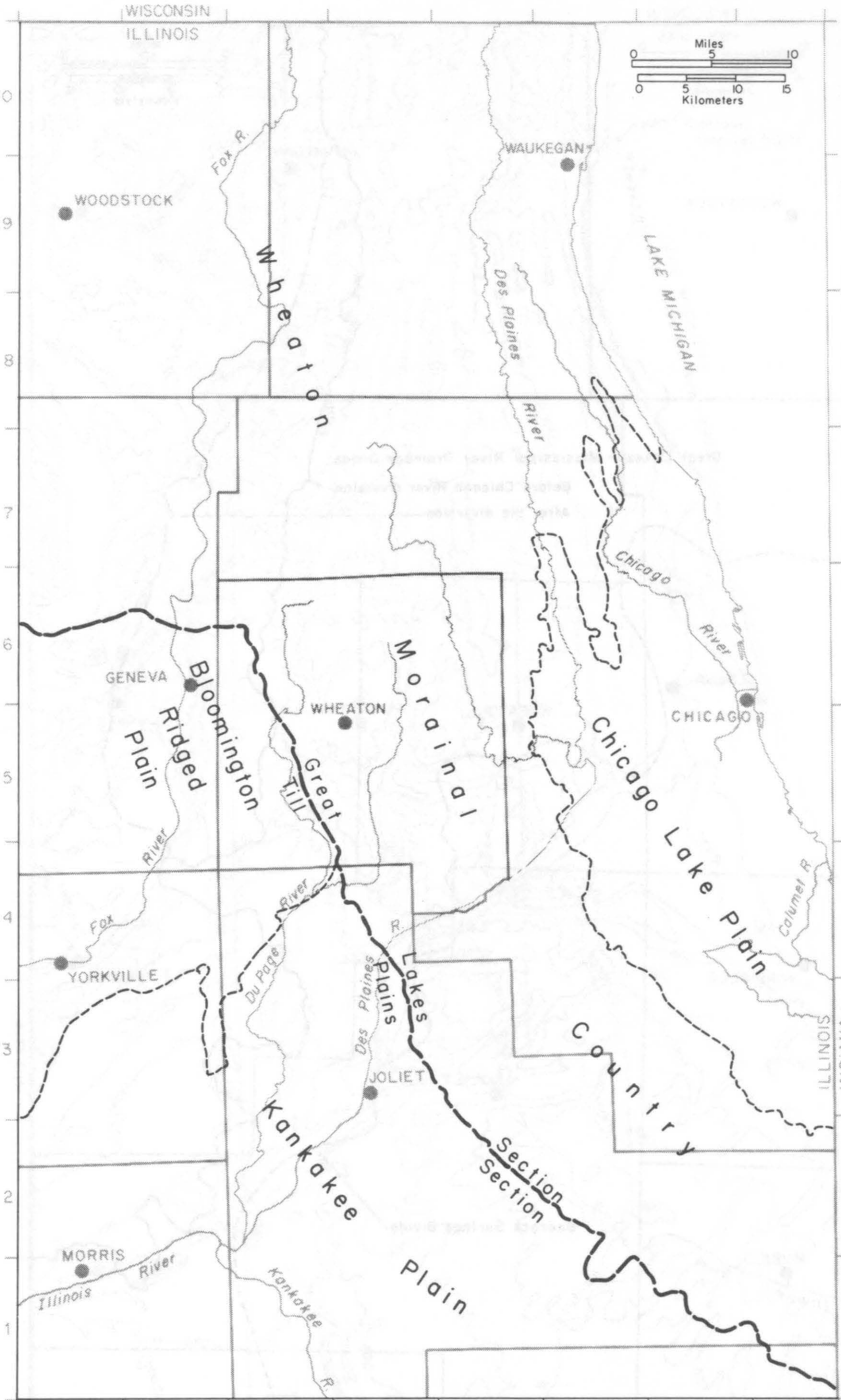


Fig. 22 - Physiographic divisions in the Chicago area.

glaciated area and extends from the Appalachian Plateaus on the east to the Great Plains on the west and from the Superior Upland on the north to the Interior Low Plateaus and the Ozark Plateaus on the south. The local relief in the Central Lowland seldom exceeds a few hundred feet.

The boundary between two subdivisions of the Central Lowland, the Great Lakes Section and the Till Plains Section, passes through the Chicago area (fig. 22). The Great Lakes Section includes the area of younger glacial drift surrounding the Great Lakes that is characterized by prominent, rough-surfaced moraines and many lakes. The Great Lakes Section, therefore, includes only the youngest part of the Wisconsinan drift. The Till Plains Section includes the areas of older Wisconsinan drift, which have a more subdued glacial topography and few lakes, and also the older till plains where the glacial topography has been largely erased by erosion. The boundary between the sections follows the front of the Valparaiso Morainic System from the Indiana state line to the vicinity of West Chicago, where it is offset to the west in order to follow the front of the Marengo Moraine northward to the Wisconsin state line.

Great Lakes Section

The Great Lakes Section has two subdivisions in the Chicago area — the Wheaton Morainal Country and the Chicago Lake Plain.

Wheaton Morainal Country

The Wheaton Morainal Country has almost all the physiographic features that are formed by continental glaciers. Exceptionally rough knob and kettle topography can be seen throughout the area of the Valparaiso Morainic System (Atwood and Goldthwait, 1908; Goldthwait, 1909; Trowbridge, 1912; Bretz, 1939). Kames and kame terraces are common. Excellent examples are abundant around Fox Lake (Fox Lake Quad.), and the Fox Lake Moraine (pl. 1) is largely a complex of kames. Outstanding examples of kames occur in the area of the Gilberts Drift west of St. Charles where individual kames are as much as 100 feet high and groups of kames are 200 feet high (Elburn and Geneva Quads.).

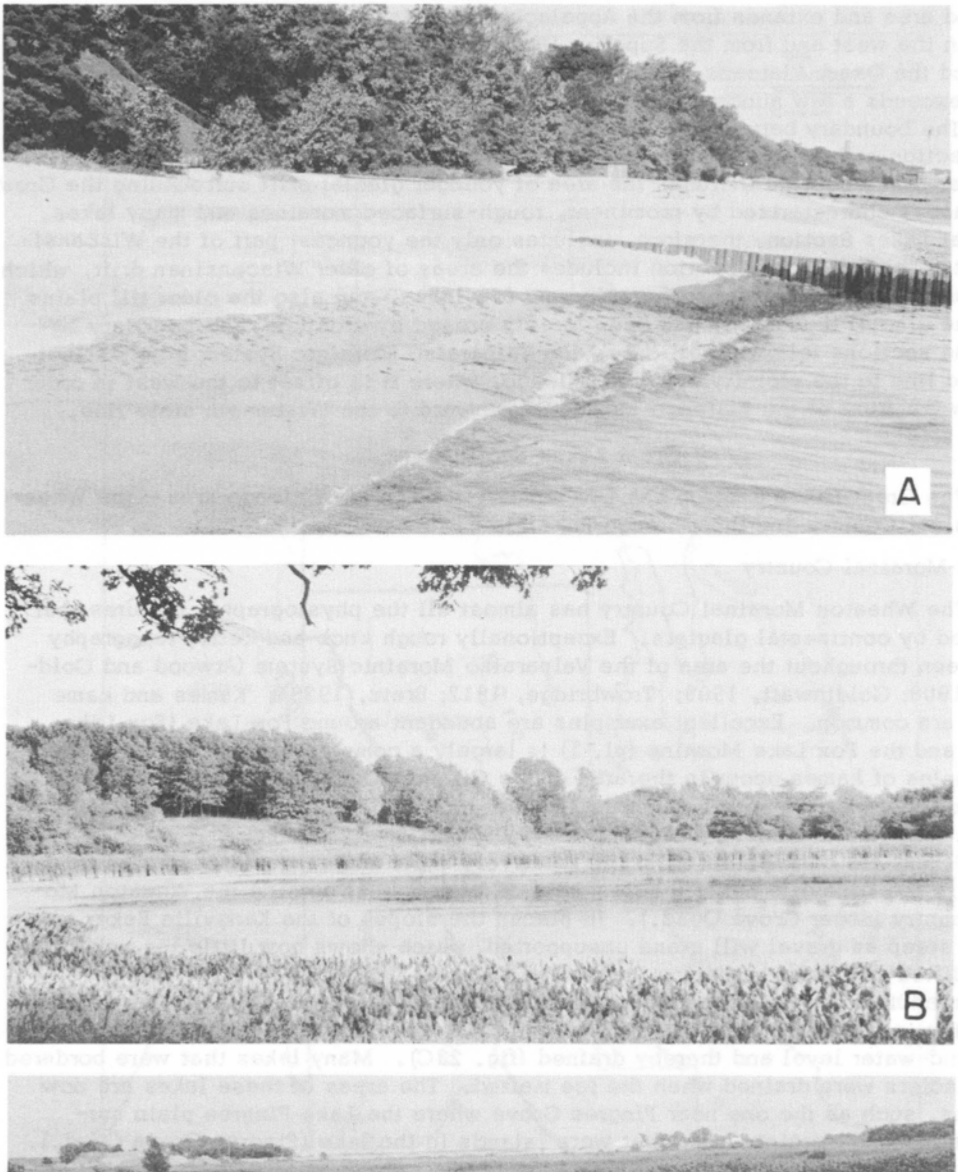
Eskers are common but most are relatively short and discontinous. The best example is the Kaneville Esker 6 miles west of Aurora, just outside the Wheaton Morainal Country (Sugar Grove Quad.). In places the slopes of the Kaneville Esker are about as steep as gravel will stand unsupported, which shows how little the esker has been modified since the bordering ice melted.

In addition to the abundant lakes still present (fig. 23 A, B), the area abounds with basins in which the lakes were filled with silt and peat to a level above the general ground-water level and thereby drained (fig. 23C). Many lakes that were bordered by the glaciers were drained when the ice melted. The areas of these lakes are now flat plains, such as the one near Pingree Grove where the Lake Pingree plain surrounds kames and morainic hills that were islands in the lake (Pingree Grove Quad.).

Chicago Lake Plain

The Chicago Lake Plain was the floor, or bottom, of glacial Lake Chicago. The lowest areas, close to Lake Michigan, also were covered by Lakes Algonquin, Nipissing, and Algoma. The Chicago Lake Plain is exceptionally flat, about 45 miles long, and a maximum of 15 miles wide. It covers about 450 square miles, 90 percent of which is covered by built-up areas of Chicago and its suburbs.

The lake plain covers all the area behind the Tinley Moraine that is below an elevation of 640 feet, the highest level (Glenwood lake stage) of Lake Chicago. The lake plain lowers to the level of Lake Michigan at 580 feet, largely in two sharp steps about 20 feet high — the shorelines of the Calumet lake stage at 620 feet and the Toleston lake stage at 600 feet. The border of the lake plain is marked by a sharp rise to the morainic topography, but it is less distinct along the northern side where branches of the lake extended up the Des Plaines and Chicago Rivers between the Lake Border Moraines.


A
B
C

The lake plain is almost entirely uneroded by modern streams. Even the major rivers — the Des Plaines, Chicago, and Calumet — flow almost on the surface of the plain.

The lake plain has low, gently sloping ridges, most of them less than 10 feet high. The ridges were spits and bars in the lake. The major ones are differentiated as the Dolton Member of the Equality Formation on plate 1. The ridges are inconspicuous, and many have been obliterated in the areas now covered by the cities. Fortunately many were mapped at an early date and were shown in the Chicago Folio by Alden (1902). Later they were shown by Bretz (1943) on improved topographic maps.

Several nearly circular or oval mounds that rise above the Chicago Lake Plain consist of Silurian bedrock that protrudes through the glacial deposits. The mounds are Silurian reefs, or parts of reefs. A hill of this type is called a klint (the plural is klintar), after similar hills in Sweden (Bretz, 1939). The hills at Thornton (Harvey and Calumet City Quads.) and Stony Island (Lake Calumet Quad.) are typical and are the best exposed. Others along the margin of the lake plain at Chicago Heights (Calumet City Quad.), La Grange (Berwyn Quad.), and Hillside (Hinsdale Quad.) are partially exposed, as are a few in the morainic areas near the lake plain at Sag Bridge (Sag Bridge Quad.), along Flag Creek south of Hinsdale (Hinsdale Quad.), and at Elmhurst (Elmhurst Quad.).

The Thornton and Stony Island klintar rise 20 to 25 feet above the surrounding lake plain, but their slopes continue downward beneath the glacial deposits for 25 to 50 feet more to the general level of the bedrock surface. As their tops are flat and glacially striated, they may have been higher. In both the Thornton and Stony Island klintar the shape of the hill conforms to the original shape of the reef. The reef-flank beds dip steeply and radially away from a central core and are approximately parallel to the slopes on the sides of the klint.

The reefs stood out in relief on the floor of the Silurian seas but later were completely surrounded and buried by younger bedrock deposits. Consequently, they now are exhumed hills that owe their present form to the superior weather resistance of the reef-type dolomite and to the radial dip of the beds.

Till Plains Section

In the Chicago area the Till Plains Section has two subdivisions — the Bloomington Ridged Plain and the Kankakee Plain — only relatively small parts of which are in the Chicago area (fig. 22).

Bloomington Ridged Plain

The Bloomington Ridged Plain is the area of older Wisconsinan drift that is less rugged and has fewer lakes than the Wheaton Morainal Country. Although the scarcity of lakes is in part due to the older age of the drift, the gentler slopes and lower relief of the surface of the moraines are the result not of greater erosion but of slower melting of the ice and less stagnation at the front of the glacier. However, near the major valleys there is more dissection by streams than in the younger drift.

The Marseilles and Minooka Moraines in the Aurora South Quadrangle are typical of the moraines in the Bloomington Ridged Plain. In the same area the sharp dissection by streams that have an unusually high gradient is shown by tributaries of the Fox River that have eroded headward into the front of the Marseilles Moraine.

Fig. 23 - Features of lakes

A - Beach of Lake Michigan showing the Ravinia Sand Member of the Lake Michigan Formation, in Elder Lane Park, New Trier (Evanston Quad.). The bluffs are eroded in the Lake Border Drift.

B - Lake (Crawdad Slough) in Valparaiso Moraine, 1 mile south of Willow Springs on Forest Island (Palos Park Quad.) showing the encroachment of swamp vegetation.

C - Peat swamp in late stage of filling a lake, at type locality of Grayslake Peat 1 mile southeast of Grayslake (Grayslake Quad.).

Kankakee Plain

The Kankakee Plain in the southwest part of the Chicago area is a comparatively flat surface between the Marseilles Moraine and the Valparaiso Morainic System. It is roughly the area covered by the Lake Wauponsee stage of the Kankakee Flood (fig. 16). All the area below an elevation of about 650 feet, the highest level of Lake Wauponsee, is included in the Kankakee Plain.

The Kankakee Plain generally slopes from its margins to a central area about 100 feet lower, where the Des Plaines and Kankakee Rivers meet to form the Illinois River. These rivers are only slightly entrenched in the central part of the plain, but where they enter and leave the plain they are more deeply entrenched. Because of its basin-like form, the part of the Kankakee Plain in the Chicago area is also called the Morris Basin.

The Kankakee Plain includes the flat-topped southern part of the Minooka Moraine and the segments of the Rockdale, Wilton Center, and Manhattan Moraines that were in part covered by Lake Wauponsee or were islands in it.

The lake plain includes beaches, bars, and erosional benches along the shorelines of Lake Lisbon, Lake Morris, and Cryder Lake. The lower part of the plain close to the major rivers contains sand and gravel ridges that were bars in the Kankakee Flood and in the Chicago Outlet River. Ridges along both sides of the Illinois River east of Morris are typical (Morris and Coal City Quads.).

The wind has blown sand from these deposits into dunes in several areas mapped as Parkland Sand on plate 1. Dunes are well developed west and south of Wilmington (Wilmington Quad.).

MINERAL RESOURCES

The Chicago area contains large resources of the common building materials — stone, gravel, sand, and clay — and a large mineral industry produces materials that were valued at nearly $100,000,000 in 1969. About a third of this production is in crushed stone, a fifth in sand and gravel, an equal amount in clay products, and the balance in other mineral products. Coal formerly was a major product, but in recent years it has declined to only minor significance in the area of this report. Water is a major mineral resource and enormous quantities are produced from both ground-water and surface-water sources, but no estimation of value is available

The value of mineral production in the Chicago area by counties in 1969 (Busch, 1971) was as follows:

Cook	$ 50,021,441
Du Page and Grundy	10,732,201
Kane	13,014,010
Kendall	446,361
Lake	1,965,027
McHenry	6,634,955
Will	12,397,499
Total	$ 95,211,494

Only a small part of this production was from parts of the counties outside the Chicago area. A general summary of the mineral resources and mineral industries in northeastern Illinois (Major, 1968) covers most of the area of this report; Kendall and Grundy Counties are included in another report (Major, 1967).

The growth of the cities puts an ever-increasing demand for building materials on the local resources, and long-range planning requires conservation of these resources, all of which are exhaustible. Expansion of the cities over favorable quarry and pit sites will eventually make it necessary to obtain materials from more distant localities or to produce them from sites that have much thicker overburden. Either alternative will greatly increase costs (Risser and Major, 1967). Land reserved for re-

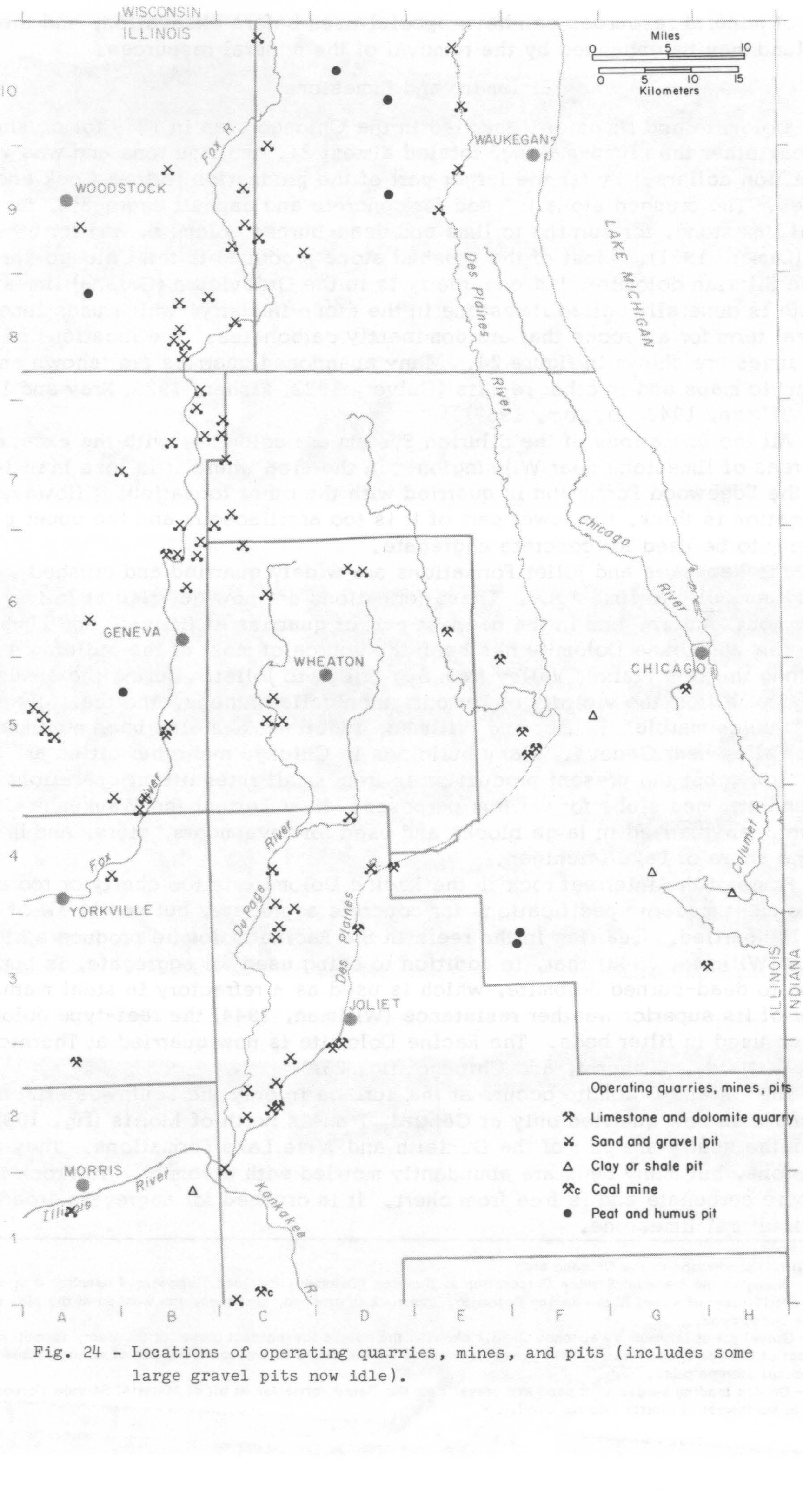


Fig. 24 - Locations of operating quarries, mines, and pits (includes some large gravel pits now idle).

covery of mineral resources can have special uses before excavation, and the value of the land may be enhanced by the removal of the mineral resources.

Dolomite and Limestone

Dolomite and limestone quarried in the Chicago area in 1969 for crushed stone purposes, other than lime-making, totaled almost 21.9 million tons and was valued at 32.8 million dollars. By far the larger part of the production is from Cook and Will Counties. The crushed stone is used for concrete and asphalt aggregate, for agricultural limestone, for burning to lime and dead-burned dolomite, and for other purposes (Lamar, 1961). Most of the crushed stone produced in the Chicago area comes from the Silurian dolomite, but one quarry is in the Ordovician (Galena) limestone. Dolomite is generally called limestone in the stone industry, which uses limestone as a general term for all rocks that are dominantly carbonates. The locations of operating quarries are shown in figure 24. Many abandoned quarries are shown on the topographic maps and in other reports (Culver, 1922; Fisher, 1925; Krey and Lamar, 1935; Willman, 1943; Ostrom, 1957).

All the formations of the Silurian System are dolomite, with the exception of local areas of limestone near Wilmington. In the area where it is less than 10 feet thick, the Edgewood Formation is quarried with the other formations. However, where the formation is thick, the lower part of it is too argillaceous and the upper part is too cherty to be used for concrete aggregate.

The Kankakee and Joliet Formations are widely quarried and crushed for aggregate and agricultural limestone. These formations are now quarried at Joliet, Lockport, Lemont, Aurora, and in the deepest part of quarries at Hillside and Elmhurst.

The Waukesha Dolomite has been the source of most of the building stone produed along the Des Plaines Valley from Sag Bridge to Joliet. During the 1800s a large quantity came from the vicinity of Lemont, then called Athens, and the stone was called "Athens marble" (Lamar and Willman, 1955). It has also been produced along the Fox Valley near Geneva. Many buildings in Chicago and other cities are built of this stone, but the present production is from small intermittent operations that produce hand-trimmed slabs for various purposes. Near Lemont the Waukesha Dolomite has also been quarried in large blocks and used for revetments, piers, and breakwaters along the shore of Lake Michigan.

Some of the interreef rock in the Racine Dolomite is too cherty or too argillaceous to meet modern specifications for concrete aggregate, but nearly all of the formation is quarried. Quarries in the reefs in the Racine Dolomite produce a high-purity dolomite (Willman, 1943) that, in addition to being used for aggregate, is burned to lime and to dead-burned dolomite, which is used as a refractory in steel manufacture. Because of its superior weather resistance (Willman, 1944) the reef-type dolomite has also been used in filter beds. The Racine Dolomite is now quarried at Thornton, La Grange, Hillside, Elmhurst, and Chicago (fig. 25A).

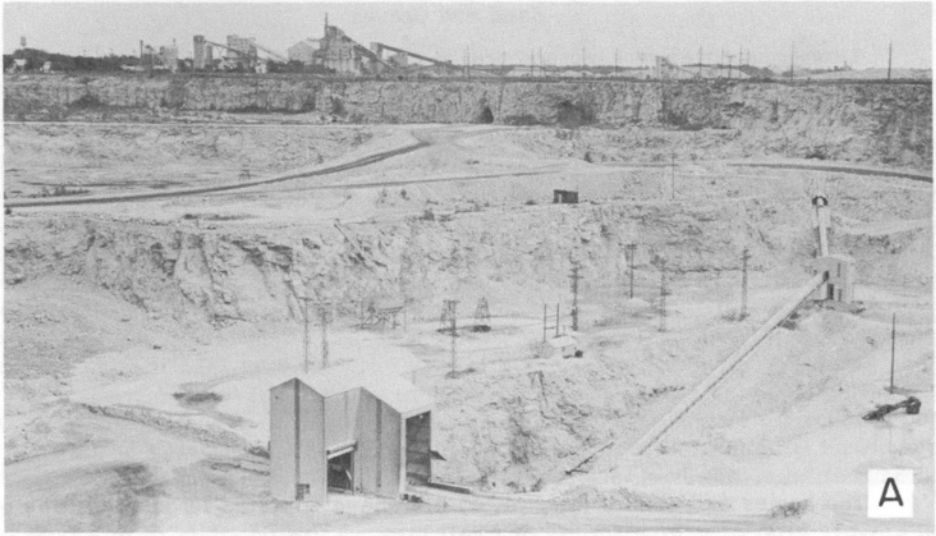
The Galena Dolomite occurs at the surface in only the southwestern part of the area, and it is now quarried only at Central, 7 miles north of Morris (fig. 10B). The strata in the quarry are part of the Dunleith and Wise Lake Formations. They are largely limestone, but many beds are abundantly mottled with dolomite. The rock is relatively pure carbonate and is free from chert. It is crushed for aggregate, roadstone, and agricultural limestone.

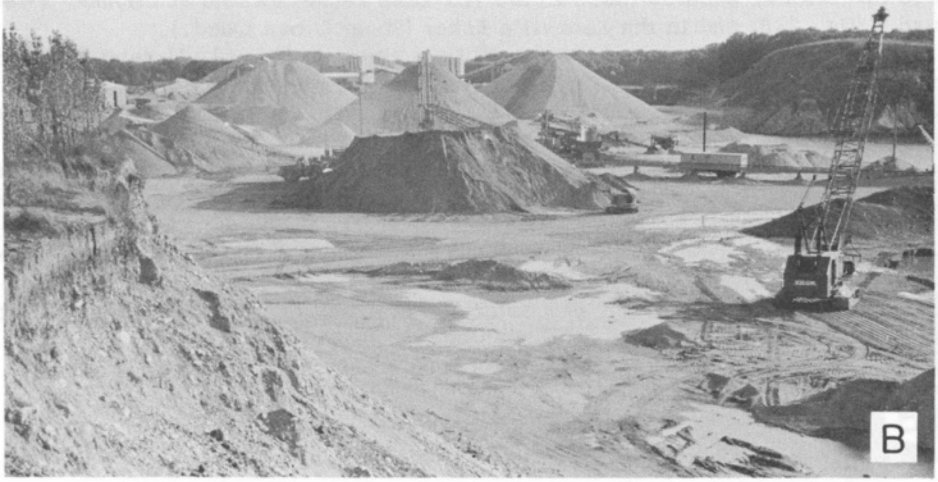
Fig. 25 - Mineral production in the Chicago area

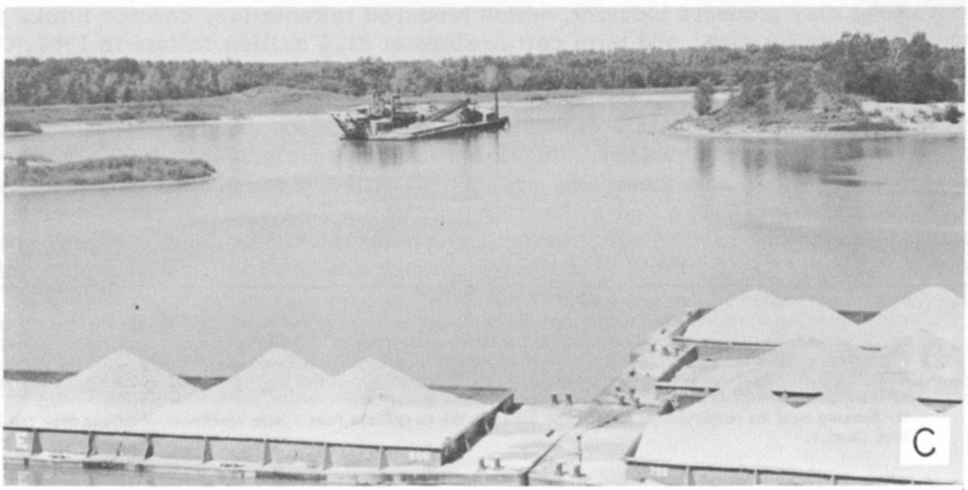
A - Quarry of the Material Service Corporation at Thornton (Calumet City Quad.) showing 4 benches that expose about 150 feet of a reef in the Racine Dolomite. The rock is crushed, screened, and washed at the plants in the background.

B - Gravel pit at Lilymoor (Wauconda Quad.) showing the coarse ice-contact gravel of the Henry Formation at the front of the Fox Lake Moraine. The gravel is crushed and screened to produce materials of various sizes in the conical storage piles.

C - Dredge loading barges with sand and gravel from the Henry Formation at pit of Material Service Corporation 1 mile southwest of Morris (Morris Quad.).







Sand and Gravel

Large quantities of sand and gravel are produced in the Chicago area for road building and concrete construction, for making mortar and plaster, and for many other purposes. In 1969 more than 20.6 million tons of sand and gravel valued at 21.2 million dollars was produced.

The extensive outwash plains on the uplands and the terraces along the major valleys (hb and hm, pl. 1) have been the major sources of sand and gravel. The principal deposits are west of the Valparaiso Moraine, except in McHenry County and parts of Kane and Lake Counties where an extensive outwash deposit of sand and gravel is overlain by thin Valparaiso till (wct, cat, vgt, pl. 1). Large gravel pits are in operation near Crystal Lake and Algonquin (Crystal Lake Quad.), Elgin (Streamwood and Geneva Quads.), Plainfield (Normantown and Plainfield Quads.), and Channahon (Channahon Quad.). Outwash deposits overlain by Illinois River alluvium are dredged near Morris (Morris Quad.) (fig. 25C). Some large deposits have been exhausted. Flathead Mound, for example, a prominent terrace remnant in the Des Plaines Valley west of Rockdale (Channahon Quad.), which was more than a mile long, half a mile wide, and 50 feet high, has been entirely removed.

The kames and eskers (hw, pl. 1) also have supplied large quantities of sand and gravel, most of it from scores of small pits. A few deposits of this type support large operations, such as those in the Fox Lake kame-moraine at Lilymoor (Wauconda Quad.) (fig. 25B) and in the Kaneville Esker (Sugar Grove Quad.).

The beaches, bars, and spits of Lake Chicago (ed, pl. 1) have been worked largely for sand in many small pits, but most of them have been overgrown by the city. Sand is now being excavated from the Glenwood spit east of Chicago Heights (Calumet City Quad.).

Dune sand (pl, pl. 1) on some of the beaches in the southern part of the lake plain has been excavated for use in fills. Sand and fine gravel have been dredged from the floor of Lake Michigan, but there is no production from this source at present.

The locations of operating pits and some larger pits worked recently are shown on figure 24. Numerous other pits, some of which are operated intermittently, are shown on the topographic maps. The character and distribution of sand and gravel deposits and the location of many pits have been shown in several reports (Trowbridge, 1912; Culver, 1922; Fisher, 1925; Block, 1960; Anderson and Block, 1962; Ekblaw and Lamar, 1964).

Clay and Shale

Glacial till and Pennsylvanian clay and shale have been used for many years in the manufacture of clay products in the Chicago area. The Chicago area has a large and varied clay products industry, which produced refractories, common brick, pottery, whiteware, sewer pipe, and terra cotta valued at 21.6 million dollars in 1969. Only the common brick and refractory brick are made from clay mined in the Chicago area.

The glacial till underlying the Lake Chicago plain, and the overlying lake silt, clay, and sand where they are present, has been used for many years in the manufacture of common brick (fig. 26B). Common brick has been produced from more than 50 pits, most of which have been long abandoned, filled, and overgrown by the city. In the middle and late 1800s and in the first part of the 20th century, large quantities of common brick were used in construction of homes, apartments, and business and factory buildings. Twenty brick plants were operating in the 1930s, but, with a shift to

Fig. 26 - Mineral production in the Chicago area

A - Large bucket-wheel excavator of the Peabody Coal Company used in strip mining the Colchester (No. 2) Coal south of Braidwood (Wilmington Quad.). The bucket-wheel excavator removes the glacial drift (till and sand) and overcasts it on waste piles of the bedrock formations (shale and siltstone) made by the dragline in the background.

B - Digging clay for the manufacture of common brick. The pit is in till of the Wedron Formation and is operated by the American Brick Company at Dolton (Lake Calumet Quad.).

C - Digging peat for horticultural uses. The pit is in the Grayslake Peat 1 mile southeast of Orland Park (Tinley Park Quad.).


PEABODY
A
B
C

other building materials, the production of common brick has declined. However, large quantities are still produced at three plants near Dolton, Blue Island, and Stickney (fig. 24).

Because the glacial till contains carbonates, it is not suitable for the manufacture of face brick. Face brick, manufactured elsewhere in Illinois from clays and shale of Pennsylvanian age, is shipped into the Chicago area. Some of the overburned Chicago common brick has a rustic or antique appearance that has recently made it popular for facing houses.

Pennsylvanian clays and shales in the Chicago area have been used in the manufacture of refractory brick, tile, and pottery. At Goose Lake, 4 miles north of Coal City (Coal City Quad.), refractory brick, refractory clay, and bonding clay are produced from Pennsylvanian clays that occur below the Colchester (No. 2) Coal.

At Coal City, the Francis Creek Shale, the roof shale of the No. 2 Coal, was used with clay from a pit in the western part of the Goose Lake area to manufacture hollow building tile and drain tile. The shale was taken from a waste pile of an abandoned underground coal mine. The waste piles of the underground mines in this area are dominantly shale, because the longwall method of mining the thin No. 2 Coal required the continual removal of roof shale. Most of the area where the Francis Creek Shale was under thin overburden in the area of this report has been strip mined to recover the coal (Coal City and Wilmington Quads.). The shale in the strip-mine waste piles is mixed with too much glacial till, sand, and gravel to be used for clay products.

Little is known about the production at Jugtown, a pioneer operation 4 miles east of Morris (Coal City Quad.), but presumably jugs were manufactured from Pennsylvanian clay or shale.

Coal

The Colchester (No. 2) Coal in the Wilmington area is the source of coal nearest to Chicago, and it has been mined since the middle 1800s. For many years it was mined from shallow shafts by the longwall method of mining (Cady, 1915). To avoid long haulage underground, many shafts were sunk, and the locations of mines are indicated by the conical waste piles that dot the landscape near Coal City and Braidwood (Coal City and Wilmington Quads.).

Since the 1920s the coal has been mined entirely by stripping (W. H. Smith, 1968). It has been stripped from an area 1 to 2 miles wide extending from the Mazon River southeastward about 10 miles to the boundary of the Chicago area (pl. 1) (Coal City and Wilmington Quads.) and from an area extending northeast from Morris for 2 miles (Morris and Lisbon Quads.). In much of the area stripped, the coal was $2\frac{1}{2}$ to 4 feet thick and had an overburden less than 50 feet thick. In recent years, larger equipment (fig. 26A) has permitted stripping nearly 100 feet of overburden. The major operations have recently moved south of the boundary of the Chicago area (pl. 1). However, the coal is still present in more than 60 square miles of the Chicago area south and west of the strip-mined areas, but most of it is at depths of 100 to 200 feet.

Peat and Humus

Deposits of peat, humus, and organic silts (muck) are widely present in the Chicago area. Many are mapped as the Grayslake Peat Formation on plate 1, but many more were too small to map on the scale of plate 1. Peat deposits are particularly abundant in the numerous lake basins in McHenry and Lake Counties (fig. 23C), but they are common in all counties in the area. In early times the peat was dried and used for fuel. It has also been used as a packing material. At present it is used mostly for horticultural purposes — to add organic matter to the soil, to conserve soil moisture, and to make clayey soils more friable (Hester and Lamar, 1969). Peat has been dug intermittently in scores of localities. At present it is dug at six localities — near Grayslake, Antioch, and Mundelein in Lake County, Woodstock in McHenry County, Batavia in Kane County, and Orland Park in Cook County (figs. 24 and 26C).

Ground Water

The water supplies of the Chicago area come largely from Lake Michigan and from wells that tap ground-water resources. The smaller lakes in the area are a source of water for some communities. Artificial lakes provide limited quantities of water for local use. The rivers and streams supply little water suitable for uses other than cooling in power plants. A limited amount of water is diverted from Lake Michigan to maintain flow through the Chicago Sanitary and Ship Canal.

The ground-water resources are in four major water-yielding units, called aquifers: (1) sand and gravel beds in the glacial drift; (2) the Shallow Dolomite Aquifer, mainly the Silurian dolomite; (3) the Cambrian-Ordovician Aquifer, in which the Ironton-Galesville and Glenwood-St. Peter Sandstones are the most productive units; and (4) the Mt. Simon Aquifer, which consists of the Mt. Simon Sandstone and the basal sandstone of the Eau Claire Formation (Suter et al., 1959).

The shallow aquifers are connected hydrologically and are recharged directly by seepage from precipitation. They are separated by the relatively impervious Maquoketa Group Shale from the Cambrian-Ordovician Aquifer. The Cambrian-Ordovician Aquifer rises westward and it is recharged at the surface or through glacial deposits west of the outcrop area of the Maquoketa Group Shale along the western side of the Chicago area (fig. 9). The Cambrian-Ordovician Aquifer is separated from the Mt. Simon Aquifer by the shaly and silty beds of the Eau Claire Formation that prevent flow between the aquifers. The Mt. Simon Aquifer has a higher artesian pressure than the other aquifers, but the water quality in the eastern part of the area is not acceptable for many uses. It is recharged largely from the outcrop region of Cambrian rocks in central southern Wisconsin (fig. 1).

The Cambrian-Ordovician Aquifer has been the most highly developed bedrock aquifer. Artesian pressure in the aquifer caused the first deep well drilled in Chicago to flow with a head 80 feet above the surface, but by 1959 the water surface had declined as much as 660 feet in a cone-shaped region around the area of heaviest pumping. On the other hand, about 60 percent of the total pumpage in the area is from the two shallow aquifers, and in them there is no widespread decline in water levels.

The geology, hydrology, and resources of ground water in the Chicago area have been discussed in detail by Suter et al. (1959) and Zeizel et al. (1962).

ENGINEERING GEOLOGY

The design of buildings, roads, dams, bridges, and subways — in fact, of all kinds of structures — is dependent on the properties and variations of the geological formations on or in which they are built. Specific conditions at each site must be evaluated for the particular structure being planned. The engineering geologist may employ test drilling, rock core and soil sample studies, and in some instances geophysical logging and laboratory testing, to evaluate the geologic conditions that must be considered in design and construction.

Major engineering problems in the Chicago area have included the design of foundations for skyscrapers, most of which require excavation through 50 feet or more of glacial deposits (largely till but including water-bearing sands and boulder accumulations) to an uneven bedrock surface. Large buildings in areas of deeper drift are placed on piling, generally driven to bedrock. Glacial till provides adequate foundations for smaller buildings and most houses.

Construction of the Chicago subway involved many problems concerned with variations in the properties of the glacial drift (Peck and Reed, 1954). Similar problems are involved in highway and bridge design and in the construction of dams (W. C. Smith, 1968, 1969). Study of the variations in the glacial drift has been important in constructing foundations for the 200 BEV accelerator at the Na-

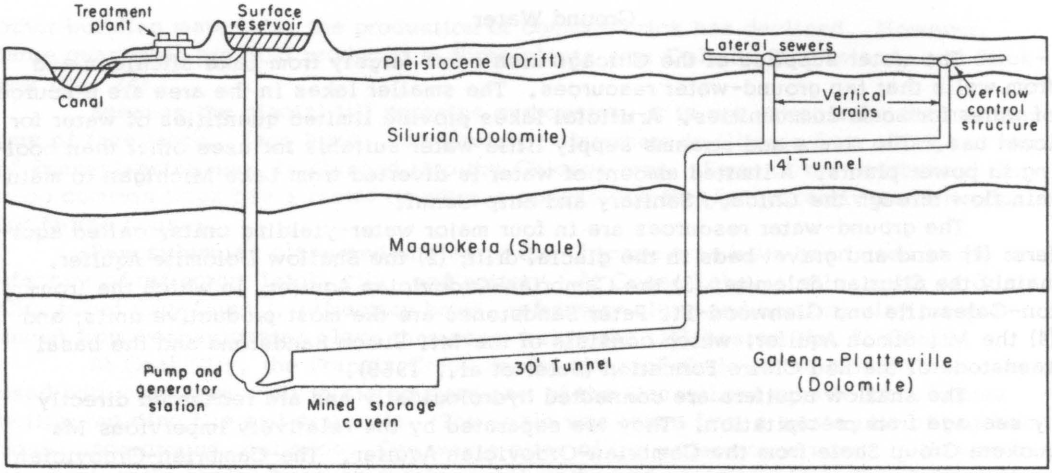


Fig. 27 - Diagrammatic sketch showing a proposed plan for flood and pollution control in the Chicago area and its relation to the major geologic units. The storage cavern would be about 800 feet below the surface. (Interpreted by T. C. Buschbach).

tional Accelerator Laboratory near Batavia (Landon and Kempton, 1971). Recent research includes study of hydrogeologic data on landfills (Hughes, 1967; Hughes, Landon, and Farvolden, 1969).

Engineering problems concerned with bedrock formations include the selection of sites and favorable formations for the excavation of deep caverns for storage of liquid petroleum gas. One underground storage cavern is now in operation near Lemont, and another is under construction near Morris.

A proposed plan for flood and pollution control in the Chicago area calls for a system of 14-foot gathering tunnels in the Silurian dolomite and 30-foot tunnels and mined caverns in the Galena-Platteville dolomites for storage of floodwaters until they can be treated and discharged to the surface drainage (fig. 27).

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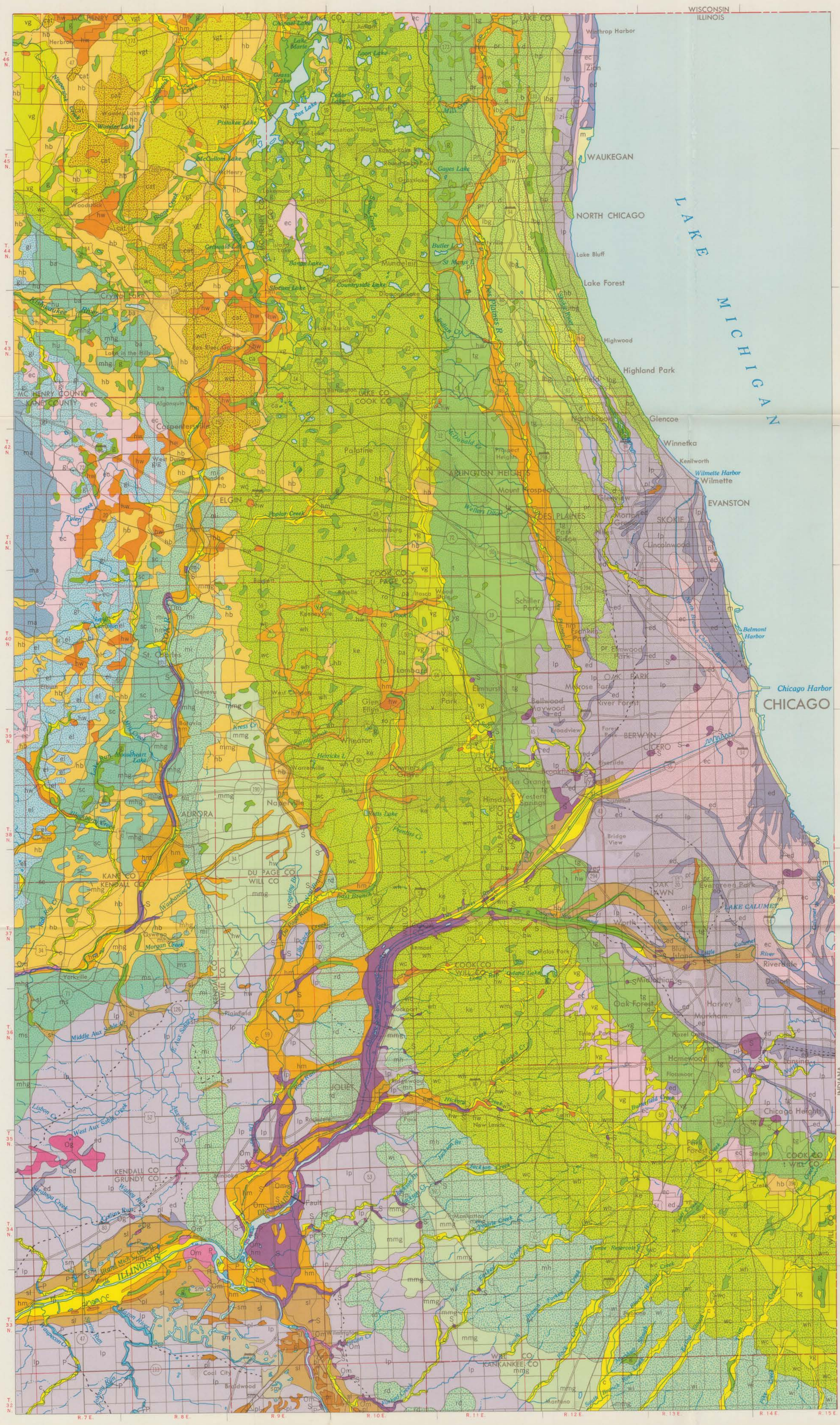
CIRCULAR 460

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA 61801

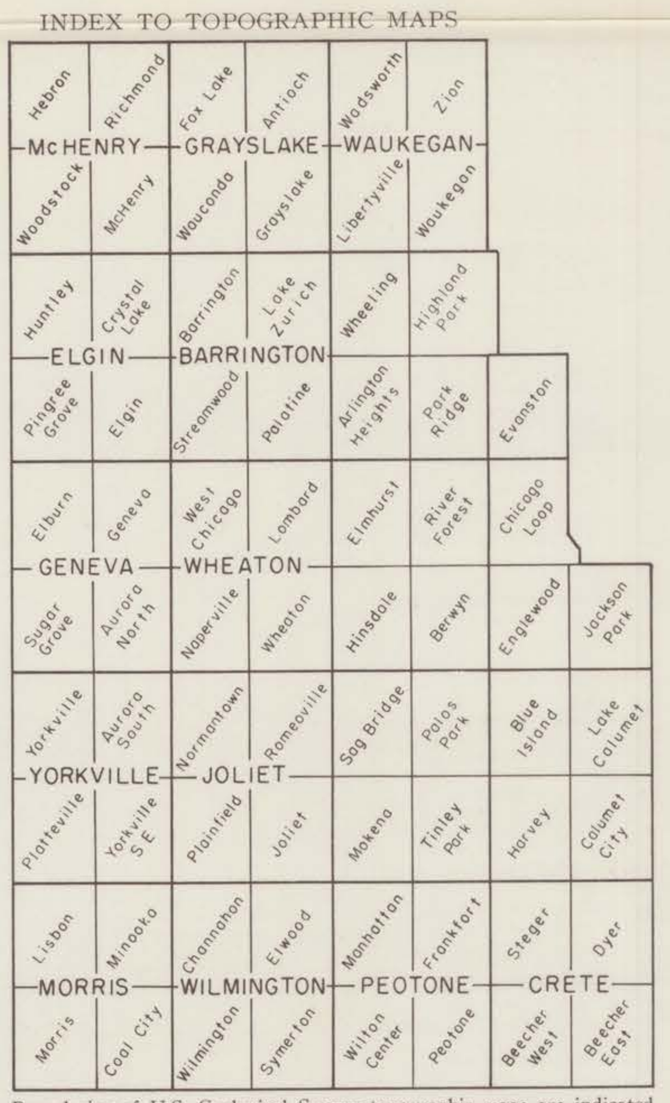
ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief — Urbana, Illinois 61801



Base map modified from parts of the Aurora (1961), Chicago (1964), Racine (1962), and Rockford (1963) 1 x 2 degree maps prepared by the Army Map Service, Corps of Engineers, U.S. Army. Compiled in part from U.S. Geological Survey Quadrangle Maps.

Densely built-up residential and commercial areas

INDEX TO TOPOGRAPHIC MAPS



Boundaries of U.S. Geological Survey topographic maps are indicated on the margin of the geologic map by tick marks. The larger maps (15-minute quadrangles) are shown in capitals above. The smaller maps are 7.5-minute quadrangles.

SCALE 1:250,000
1 inch equals approximately 4 miles

SURFICIAL GEOLOGY OF THE CHICAGO REGION

H. B. WILLMAN AND JERRY A. LINEBACK

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1970

EXPLANATION

Because many of the areas mapped are small, the conventional symbols for Quaternary units are abbreviated. Q for Quaternary and Qw for the Quaternary Wedron Formation are omitted.

SYSTEM | SERIES | STAGE | SUBSTAGE

QUATERNARY — PLEISTOCENE and HOLOCENE — WISCONSINAN and HOLOCENE — WOODFORDIAN, TWOCREEKAN, VALDERAN, and younger

m

Made land

Man-made fill; areas formerly covered by Lake Michigan and Lake Calumet; largely sand in areas bordering Lake Michigan and rubbish in area bordering Lake Calumet.

sm

Strip mine waste piles

Areas of coal strip mines; consists of the mixed overburden of the coal; largely glacial till, sand, shale, and sandstone. Many similar small areas produced by limestone quarrying, clay and shale mining, canal excavations, etc., are not mapped.

c

Cahokia Alluvium

Deposits in floodplains and channels of modern rivers and streams; mostly poorly sorted silt and sand containing local deposits of sandy gravel; in many places overlies relatively well sorted glacial outwash of the Henry Formation.

g

Grayslake Peat

Peat, muck, and locally marl; dominantly organic deposits with interbedded silt and clay in places; mostly in glacial lake basins; locally in lake basins on floodplains of major rivers.

pl

Parkland Sand

Wind-blown sand; largely well sorted medium-grained sand in dunes.

WOODFORDIAN, TWOCREEKAN, VALDERAN

Equality Formation

Lake deposits; largely silt with sand facies near shorelines; deposits of the older lakes have a thin cover of silt (Richland Loess).

ec

Carmi Member of Equality Formation

Largely quiet-water lake sediments; dominantly well bedded silt, locally laminated and containing thin beds of clay; local lenses of sand and sandy gravel along beaches.

ed

Dolton Member of Equality Formation

Largely shallow-water, near-shore lake sediments in beaches, bars, spits, and deltas; dominantly medium-grained sand; contains beds of silt where gradational to Carmi Member; local lenses of sandy gravel along beaches.

lp

Lake plain

Floors of glacial lakes flattened by wave erosion and by minor deposition in low areas; largely underlain by glacial till; thin deposits of silt, clay, and sand of the Equality Formation present locally.

Lake shoreline

Shorelines within lake plains (present but not shown at boundary of lake plains); usually consists of a slightly elevated beach ridge or an erosional scarp forming a terrace; discontinuous deposits of sand or pebbly sand of the Equality Formation generally present.

sl

Glacial sluiceway

Erosional channels; mostly outlets of glacial lakes where cut into till; where cut into bedrock, as along Illinois, Des Plaines, and Kankakee Valleys, the bedrock formation is mapped instead; contains local deposits (mostly bars) of sand and gravel of the Henry Formation.

QUATERNARY — PLEISTOCENE — WISCONSINAN — WOODFORDIAN

Henry Formation

Sand and gravel with minor and local beds of silt; largely glacial outwash but locally includes deposits of outlet rivers of glacial lakes; outwash deposits generally have a thin cover of silt (Richland Loess).

hm

Mackinaw Member of Henry Formation

Sand and gravel, generally well sorted and evenly bedded; deposits in valleys; mostly glacial outwash in terraces — remnants of valley trains; includes similar deposits in glacial sluiceways.

hb

Batavia Member of Henry Formation

Sand and gravel, well sorted; deposits in uplands; deposits of glacial meltwater rivers and streams in outwash plains.

hw

Wasco Member of Henry Formation

Sand and gravel, unevenly sorted, irregularly bedded, with variable grain size; commonly contains lenses of silt and till; glacial ice-contact deposits in kames, eskers, and kame terraces.

Wedron Formation

Mostly glacial till with lenses and beds of gravel, sand, and silt; includes all glacial deposits from the top of the surface till to the underlying Morton Loess, Farmdale Soil, or Altonian tills, which are present locally in subsurface but are rarely exposed; commonly rests directly on bedrock; generally mantled with 1 to 2 feet of leached silt (Richland Loess) and the Modern Soil; locally overlies the Lemont Drift (probably pre-Woodfordian in age), which consists of very silty, yellow-gray till, well bedded sand, and sand and gravel. Lemont Drift is exposed in narrow belts along the Des Plaines Valley and the Calumet-Sag Channel where they cut through the Valparaiso Moraine, but it is not mapped separately.

Wadsworth Member of Wedron Formation

Mostly gray clayey and silty clayey till, relatively low in content of pebbles, cobbles, and boulders; contains local lenses of silt; commonly mantled with 1 to 2 feet of leached silt (loess) and soil.

Lake Border Morainic System

zi Zion City Moraine
hp Highland Park Moraine
b Blodgett Moraine
d Deerfield Moraine
pr Park Ridge Moraine

lbg

Lake Border Groundmoraine

t

Tinley Moraine

tg

Tinley Groundmoraine

(Continued in next column)

QUATERNARY—Continued — PLEISTOCENE—Continued — WISCONSINAN—Continued — WOODFORDIAN—Continued

Wadsworth and Haeger Members of Wedron Formation

The Fox Lake and Cary Drifts and the West Chicago Drift north of West Chicago are part of the Haeger Member, largely silty, sandy, or gravelly till with local areas of silty clayey till, many lenses of poorly sorted gravel, and abundant small kames. The Fox Lake Moraine is largely a belt of kames.

The West Chicago Drift south of West Chicago and the other Valparaiso drifts are part of the Wadsworth Member but are slightly more silty and pebbly than the Lake Border Drift and contain local areas of sandy to gravelly till in the outer (older) moraines.

Valparaiso Morainic System

v Valparaiso undifferentiated

North of Du Page County

pa Palatine Moraine
f Fox Lake Moraine
ca Cary Moraine
wc West Chicago Moraine

North line of Du Page County to Des Plaines Valley

pa Palatine Moraine
ro Roselle Moraine
ke Keeneyville Moraine
wh Wheaton Moraine
wc West Chicago Moraine

South of Des Plaines Valley

cl Clarendon Moraine
wm Westmont Moraine
ke Keeneyville Moraine
wh Wheaton Moraine
wc West Chicago Moraine

cat Cary Moraine
Thin till on gravel
wct West Chicago Moraine
Thin till on gravel

vg

Valparaiso Groundmoraine

vgt

Valparaiso Groundmoraine Thin till on gravel

Yorkville Member of Wedron Formation

Mostly gray to dark gray clayey till, locally silty clayey till; contains abundant small pebbles (especially in Marseilles Drift), local lenses of silt, and less commonly lenses of sand and gravel.

mh Manhattan Moraine
wi Wilton Center Moraine
rd Rockdale Moraine
mi Minooka Moraine

mmg

Manhattan–Minooka Groundmoraine

ms Marseilles Moraine
sc St. Charles Moraine
ba Barlina Moraine
hu Huntley Moraine

mhg

Marseilles–Huntley Groundmoraine

Malden Member of Wedron Formation

Mostly yellow, tan-gray, or slightly pinkish, silty till to clayey silty till with local lenses of silt, sand, and gravel.

gi Gilberts Moraine
el Elburn Morainic Complex

gig

Gilberts Groundmoraine

Tiskilwa Member of Wedron Formation

Pink to pinkish gray, sandy silty till with local lenses of silt, sand, and gravel.

ma

Marengo Moraine

Major unconformity

PENNSYLVANIAN — ATOKAN—DESMOINESIAN

P

Kewanee Group

Carbondale (top) and Spoon Formations

Largely shale and sandstone with relatively thin beds of coal, clay, and limestone.

Major unconformity

SILURIAN — ALEXANDRIAN—NIAGARAN

S

Racine (top), Waukesha, Joliet, Kankakee, and Edgewood Formations

Largely dolomite, slightly to moderately argillaceous with scattered chert nodules; Racine Formation contains large reefs of massive to well bedded pure dolomite; minor beds of shale and shaly dolomite in lower part and locally bordering reefs in upper part; partly limestone in places near Kankakee Valley; fills pre-Silurian valleys as much as 100 feet deep in Maquoketa Shale in some areas.

Major unconformity

ORDOVICIAN — CINCINNATIAN

Om

Maquoketa Group

Neda Oolite (top), Brainard Shale, Fort Atkinson Limestone, and Scales Mound Shale

Red shale and oolite in local areas at the top; upper part largely greenish gray shale that in places grades laterally to silty argillaceous dolomite and dolomitic siltstone; limestone and dolomite with interbedded shale in middle part; largely gray to dark brownish gray shale in lower part.

Minor unconformity

CHAMPLAINIAN

Og

Galena Group

Wise Lake (top) and Dunleith Formations

Mostly pure, medium- to thick-bedded, yellow-gray to tan dolomite above; thinner bedded, slightly less pure, and locally cherty dolomite below; limestone mottled with dolomite locally south of Yorkville; oldest strata exposed in map area.

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